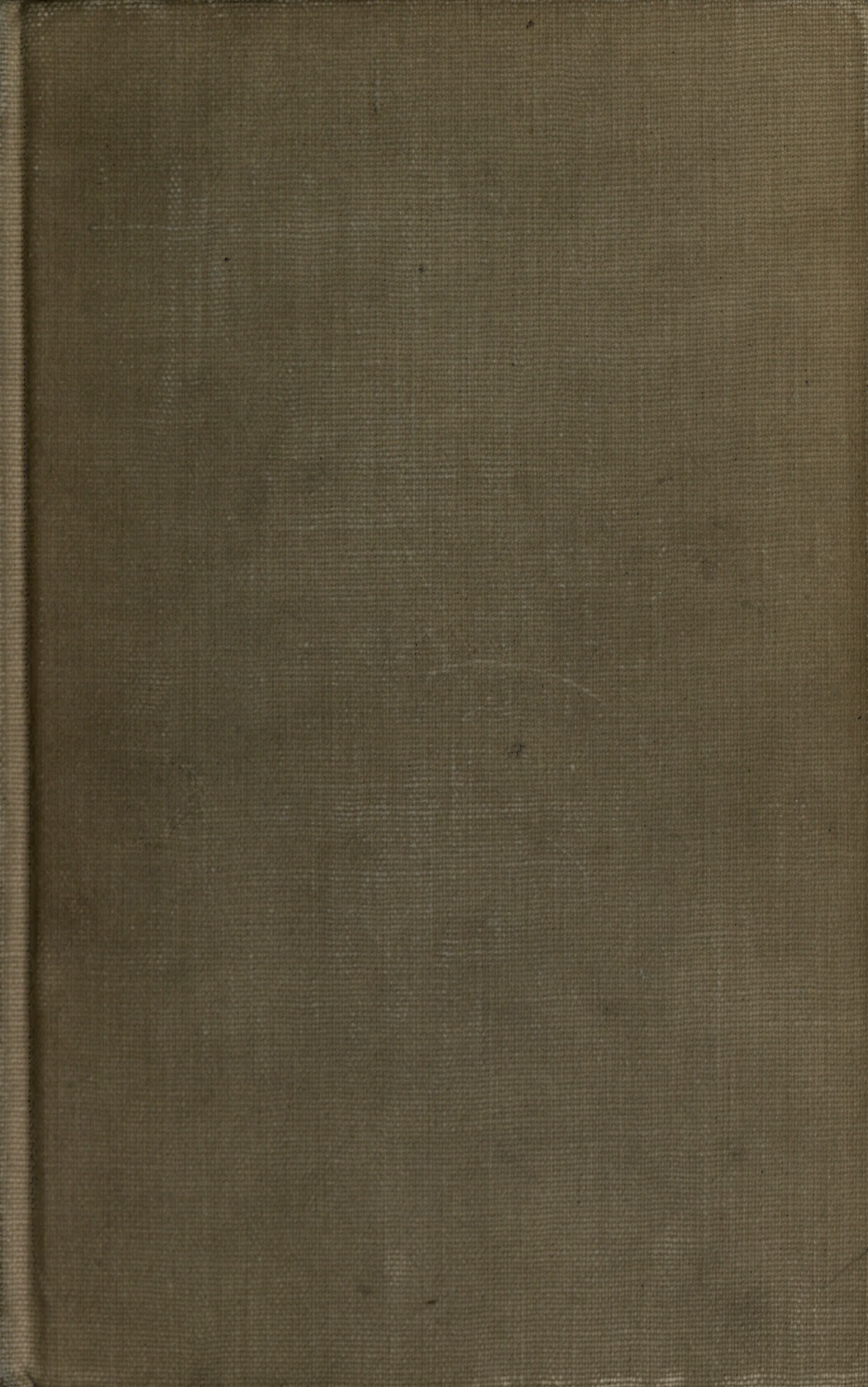




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FARMERS' BULLETINS

Nos. 1426-1450

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1426

FARM PLUMBING



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PLUMBING to-day is largely the assembling and installing of manufactured products. It requires less of the skill of the old-time lead worker and more of practical knowledge regarding house water supply and house drainage. The modern plumber must know something of hydraulics, mechanics, pneumatics, and sanitation. He must know what materials, pipes, and fixtures are most appropriate, how they may best be installed and what they cost. Five to ten per cent of the cost of a house, if fully equipped, goes into the plumbing—an expense justifying full study and information.

This bulletin is for the farmer-plumber and those desiring to follow the work where a regular plumber is employed. All the conveniences hoped for need not be put in at one time, but the work should always be planned in advance so as to combine the best arrangement at the lowest cost. A sink will naturally come first, but the plumbing should be extended to include at least a bathroom. A small spare room or closet can often be converted into a bathroom and so contribute very greatly to the convenience, comfort, and health of the whole family.

FARM PLUMBING

By GEORGE M. WARREN

Hydraulic Engineer, Bureau of Public Roads

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INTRODUCTION

FEW THINGS CONTRIBUTE MORE to our convenience and comfort than good plumbing. How much they contribute to health and longer life, none can say, but it is certainly large.

America has better plumbing than any other nation in the world, but it is unfortunate that its extension to the country has lagged far behind its use in the city. The 1920 census reports 643,899 of the 6,448,343 farms in the United States as having water piped into the house. This is only 1 farm out of 10, and means that 5,804,444 farms, or 9 out of 10, have little or no plumbing. To aid in bringing simple and good plumbing into these homes and in improving existing installations is the purpose of this bulletin.¹

The present-day tendency is toward simple, direct, standardized plumbing to combine the greatest usefulness with the least cost. This bulletin describes and illustrates the important things entering into simple, sound practice and in sufficient detail to enable those handy with tools to do their own work. It is impossible to avoid minor disagreements with some of the thousands of local plumbing ordinances, but in general the recommendations conform to well-established sanitary practice and may be accepted in most communities as leading to safe, dependable, and inexpensive plumbing.

HOME WORK

Every farmer can not do his own plumbing. A layout that looks simple on paper may be difficult to install, and in inexperienced hands often results in dissatisfaction. Many have the skill and tools to do creditable work, and may profitably utilize the service of

¹ Farmers' Bulletins, 941, Water Systems for Farm Homes, and 1227, Sewage and Sewerage of Farm Homes, may profitably be read in connection with this bulletin.

plumbing-supply and mail-order houses. This service may include

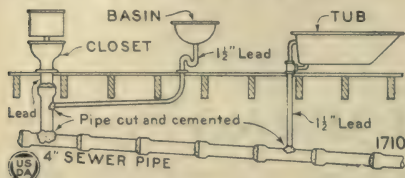


FIG. 1.—Plumbing fixtures poorly connected; the bathtub has no trap; the basin trap is subject to self-siphonage and is forced by bubbles of sewer air when the water-closet is flushed; cutting into vitrified sewer pipe makes rough, leaky, easily obstructed joints and is a poor substitute for branch fittings

should be examined very closely.

Where such exist, the farmer should study them and make his installation conform to them. The services of a good, reliable plumber are recommended as being most likely to secure a lawful, dependable, and durable job. Figure 1 shows a very poor installation. Figure 2 shows an unsightly installation but one that is serviceable in mild climates. Figure 3 shows two crude homemade sinks, and Figure 4 shows a conveniently arranged kitchen with a 1-piece sink.

DEFINITIONS OF PLUMBING TERMS

The man who undertakes to do his own plumbing will find that the first essential is an under-

standing of the terms commonly used in the plumbing trade. Without such knowledge the intelligent consultation of catalogues and the

plan, bill of materials, and estimate of cost prepared from the farmers' dimensioned sketch. This enables the supply house to ship the correct piping and fixtures and the householder to install them without great difficulty and labor. Wrecking companies often carry salvaged stocks which can be bought cheaply; but cheap plumbing is likely to prove dear in the long run, and used plumbing, like any secondhand goods, Local and State plumbing regu-



FIG. 2.—Home plumbing in Maryland, installed by one man unaided; no trouble from frost in 15 years because the faucets do not drip; the soil and vent stack is at the center of the ell; the sink waste is low and just to the left; the washstand waste is just to the right of the soil stack; the bathtub waste enters the rain conductor at the near corner and immediately above the porch roof. Outside soil stacks are unsightly but are often installed in mild and moderate climates such as in southern United States and in England

purchasing of the necessary fixtures and materials will be difficult. The terms defined below are the ones most frequently used.

Plumbing is the piping, with attachments, which conveys water into buildings and premises and carries out the sewage. Rain-water pipes are not included.



FIG. 3.—Home-made kitchen sinks in Virginia

Upper: Large dish pan partly embedded in concrete within a shallow wooden form or box; the whole is painted white and varnished with a resistant, nonabsorbent varnish.

Lower: Large enameled pan embedded in concrete formed as in the upper picture and supported by brackets; has the effect of an apron sink; note the cement plaster backing.

Fittings are pieces to join pipes, change directions, and provide openings—for example, couplings, elbows, branches.

Fixtures are appliances for making plumbing of use—for example, kitchen sinks, washstands, bathtubs—these and one to three section laundry tubs are classed as small fixtures; slop sinks, large shower baths, and water-closets are large fixtures.

A faucet, spigot, bibb, or cock is a device for drawing and stopping water.

House drain is the sloping pipe conveying all sewage through or beneath the cellar or basement and extending 5 to 10 feet outside the cellar wall.

House sewer is the house drain extended downhill.

Soil pipe is pipe conveying feces or urine but may take other wastes also.

Waste pipes are small pipe drains from fixtures other than closet bowls and urinals.

A stack is a soil, waste, or ventilating pipe in upright position.

A vent stack is (1) an extension of a soil or waste stack from the branch of the highest fixture to above the roof; (2) a special vent pipe connected with a soil or waste stack below the lowest fixture

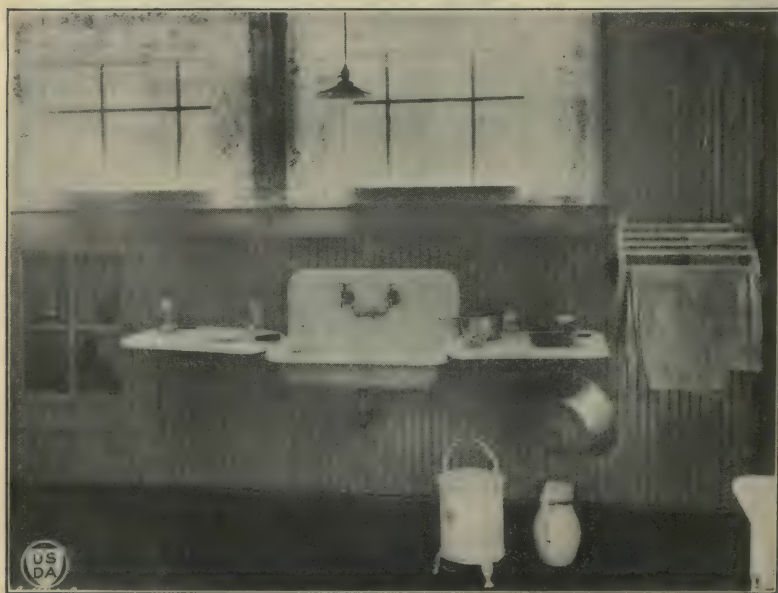


FIG. 4.—A conveniently arranged kitchen with a 1-piece sink

and above the highest fixture or extended independently above the roof.

A trap is a water-sealed bend or vessel in a waste or soil pipe close to or within a fixture to prevent vermin and sewage odor from entering rooms.

A trap vent, back vent, or back air pipe is a short rising pipe from the outlet side of a trap to a vent stack; it promotes flow of the waste water, ventilates the waste pipe, and, by equalizing air pressure, prevents trap siphonage (loss of water seal by suction) and trap blowing (caused by back pressure).

Wrought pipe is weldable pipe, either wrought iron or mild steel, screw-joint pipe usually being understood. To obtain genuine wrought iron it must be so specified.

Size of pipe refers to the nominal inside diameter.

Tubing is thin pipe, generally requiring special threads and fittings and referred to by the outside diameter (O. D.).

The head, fall, grade, or pitch of a pipe is the vertical drop in a given horizontal distance.

Static pressure is the pressure of water at rest; it equals 0.43 of a pound per square inch for each foot of head, or 1 pound for each 2.3 feet of head. The terms low pressure, medium pressure, and high pressure are herein assumed to mean static pressure, less than 20 pounds, 20 to 45 pounds, and more than 45 pounds per square inch, respectively.

Figure 5, a typical 5-fixture job, identifies the plumbing defined.

Tools.—The principal tools used by plumbers are the pouring ladle, calking tools, melting pot, vise, pipe cutter, pipe threader, reamer, pipe wrench, monkey wrench, hammer, file, and measuring tape or rule. The pipe bender and blast furnace are very handy but not absolutely essential. These and other minor tools are shown in Figure 6.

PIPE

MATERIALS, DIMENSIONS, WEIGHTS, AND COSTS

WATER PIPE

Lead.—Lead is used extensively for underground water pipes. It is enduring and easily laid, but there is danger of lead poisoning resulting from

its use. It should not be used for conveying acid waters or those of swampy or peaty origin. Even hard, feebly active waters, if long in contact with lead, may dissolve amounts sufficient to produce serious cumulative effect. Hence water standing overnight in lead pipe should never be used for drinking or cooking. Where the flow is continuous or where the lead-dissolving power of the water has been determined by a competent chemist, the use of lead pipe may be desirable and the following pipe data are given:

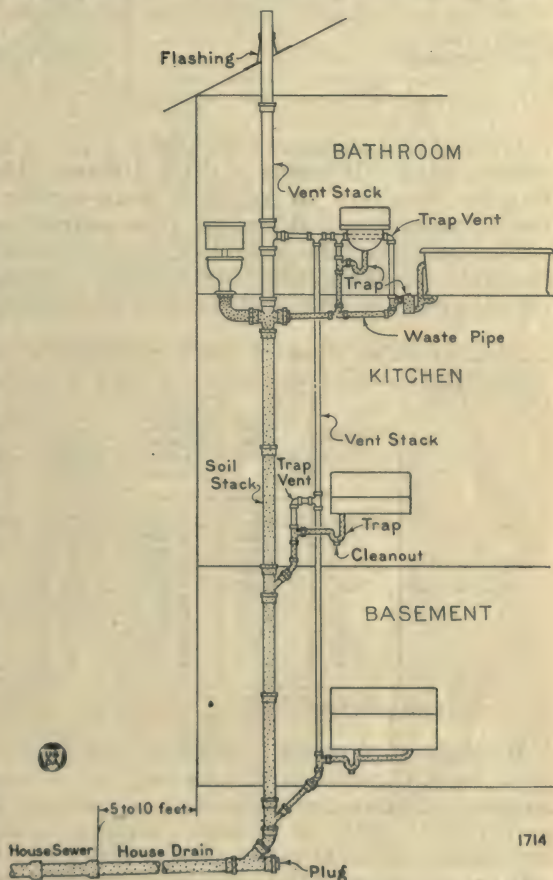


FIG. 5.—A typical 5-fixture job. Drainage pipes are stripped and vent pipes are outlined

For low and medium working pressure up to 25 or 30 pounds per square inch, lead pipe classed "strong" is suitable; for higher pressure up to 75 pounds, "extra strong" should be used.

TABLE 1.—Weight and cost of "strong" lead pipe

	Size of pipe (inches)						
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	1 $\frac{1}{4}$	1 $\frac{1}{2}$
Pounds per foot.....	1 $\frac{1}{2}$	1 $\frac{3}{4}$	2 $\frac{1}{2}$	3	4	4 $\frac{1}{2}$	6
Cost per foot (cents) ¹	17	19 $\frac{1}{2}$	28	33	44	52 $\frac{1}{2}$	66

¹ Prevailing retail price, October, 1923.

Wrought.—Galvanized wrought pipe is usually used for farm water piping. It comes in three different thicknesses or weights, as follows: Standard or regular, extra strong, double extra strong. For a given nominal size of pipe, extra strong and double extra strong have the same outside diameter as standard, thickness being gained by making the bore smaller. Standard weight is ample for all ordinary uses, and Table 2 gives dimensions and costs.

TABLE 2.—Data on standard weight galvanized, wrought iron, and steel pipes

Nominal size	Actual inside diameter	Weight per foot, threaded and coupled	Threads per inch	Cost ¹ per foot	
				Iron	Steel
<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	<i>Number</i>	<i>Cents</i>	<i>Cents</i>
1	0.493	0.568	18	11	6
	.622	.852	14	12	7
	.824	1.134	14	14	8
	1.049	1.684	11 $\frac{1}{2}$	19	11
1 $\frac{1}{2}$	1.390	2.281	11 $\frac{1}{2}$	26	15
1 $\frac{1}{2}$	1.610	2.731	11 $\frac{1}{2}$	32	19
2	2.067	3.678	11 $\frac{1}{2}$	45	25
2 $\frac{1}{2}$	2.469	5.819	8	66	38
3	3.068	7.616	8	82	48

¹ Prevailing retail price, October, 1923.

Wrought pipe comes in random lengths, averaging nearly 20 feet, with ends threaded and carrying one wrought-iron coupling per length. At extra cost, pipe is cut to specified length, with ends plain or threaded, with or without couplings, and the bore reamed and smoothed. Up to 1 $\frac{1}{2}$ inches pipe is shipped in bundles weighing from 120 to 210 pounds and averaging roughly 168 pounds. Above 1 $\frac{1}{2}$ inches pipe is shipped loose.

Cast iron.—Cast iron coated with hot coal-tar pitch varnish for underground water pipe is desirable because of its long life. Common hub-and-spigot pipes in 2 and 2 $\frac{1}{2}$ inch sizes have a laying length of 9 feet, and 3-inch and larger pipes lay 12 feet. Manufacturers test to 300 pounds per square inch, a pressure well within the strength of the pipe. For working pressures up to 100 pounds per square inch suitable weights per length of 2, 2 $\frac{1}{2}$, 3, and 4 inch pipes are, respectively, 72, 98, 175, and 240 pounds: the approximate costs per foot are, respectively, 32, 44, 58, and 80 cents.

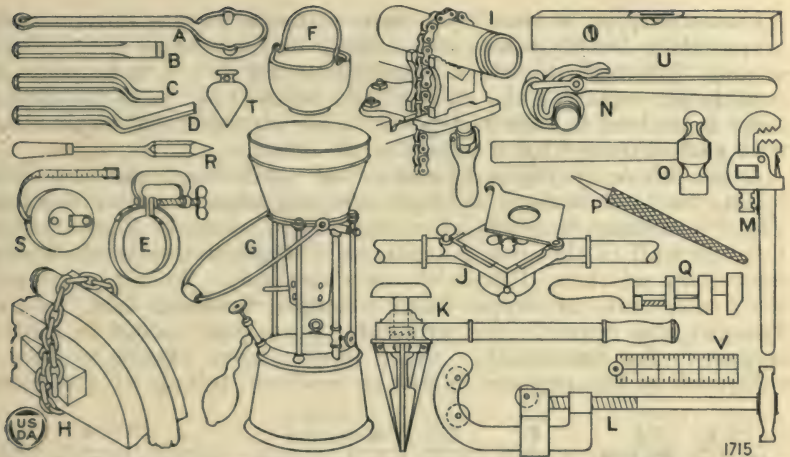


FIG. 6.—Twenty-two plumbing tools: A, pouring ladle; B, cold chisel; C, calking iron; D, yarning iron; E, asbestos or rubber pipe jointer; F, melting pot; G, gas-line blast furnace; H, home-made pipe bender; I, pipe vise; J, stock and die for threading pipe; K, pipe reamer; L, three-wheel pipe cutter; M, 14-inch pipe wrench; N, brass pipe wrench; O, hammer; P, file; Q, monkey wrench; R, soldering copper; S, measuring tape; T, plumb bob; U, spirit level; V, measuring rule. These tools cost about \$40

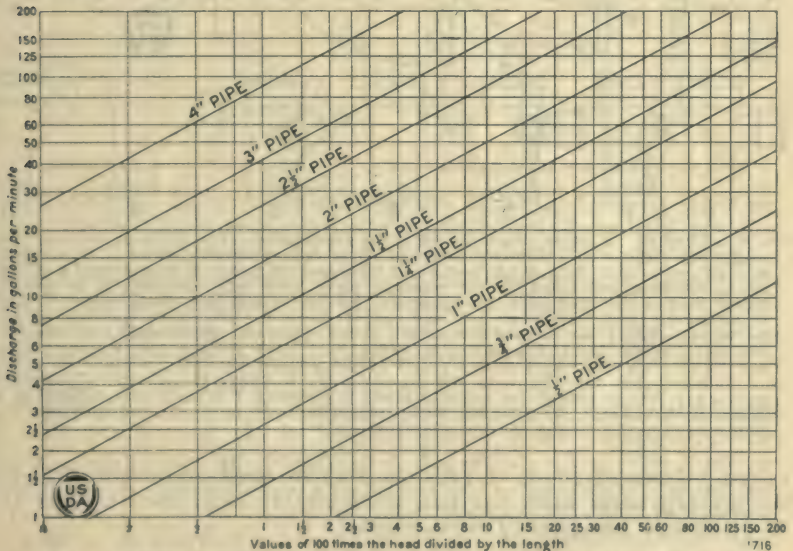


FIG. 7.—Diagram giving the discharge of $\frac{1}{2}$ -inch to 4-inch straight water pipes

Directions: Measure the vertical distance in feet from the delivery end of the pipe to the surface of the water in the spring or tank; multiply this distance by 100 and divide the product by the length of the pipe in feet; find this value on the lower horizontal line of the diagram and follow vertically upward to the inclined line or lines showing pipe sizes; from such intersection follow horizontally to the left to find the discharge in gallons per minute.

Example: How much water will be discharged by 128 feet of 1-inch pipe under a head of 32 feet?

Solution: Thirty-two multiplied by 100 equals 3,200; 3,200 divided by 128 equals 25; enter the diagram at 25, follow upward to the line marked 1-inch pipe, and then follow to the left where the discharge is seen to be 15 gallons per minute.

NOTE.—For hydropneumatic tanks the equivalent head is 2.3 feet per pound of gage pressure. Do not use the diagram for pipes shorter than 500 times their inside diameter; thus, for $\frac{1}{2}$ -inch pipe the length should be at least 250 feet; for 1 $\frac{1}{4}$ -inch pipe, at least 52 feet.

Cast-iron pipe in sizes from $1\frac{1}{4}$ to 4 inches may be obtained with prepared or factory-made joints ready for calking in the field. It is about $\frac{1}{4}$ inch thick, comes in lengths to lay 5 feet, is tested to 300 pounds per square inch, and is well adapted to farm use because there is no lead to melt and pour. This pipe may be obtained also with ends threaded for standard screw fittings.

Other kinds of pipe.—Corrosion of small steel and iron pipes results in "red water," reduced carrying capacity, and shortened life. Sometimes the bore of wrought pipe clogs or closes long before the wall of the pipe is destroyed. Pipe materials which overcome most of these difficulties are obtainable. Among such pipes are brass, brass or copper-lined wrought, tin-lined lead, tin-lined wrought, and cement-lined wrought. Brass pipe should be medium annealed; for unconcealed water pipes (from fixture to floor or wall), where the pressure is low or medium, tubing of a thickness

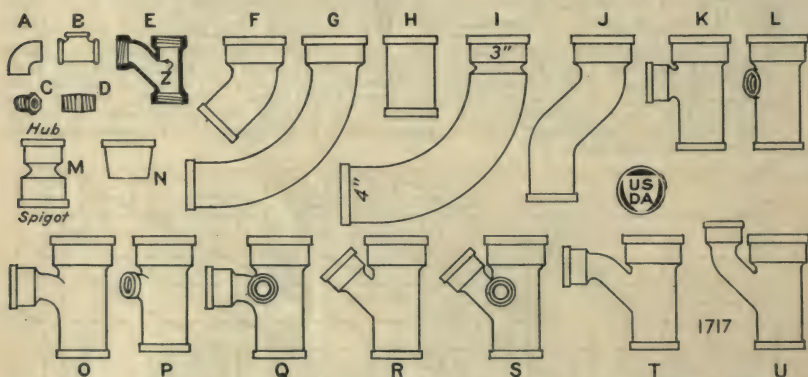


FIG. 8.—Fittings: A, plain elbow or ell, turns one-quarter of a circle or 90 degrees; B, beaded tee branch; C, shoulder bushing; D, shoulder nipple; these four are typical wrought water pipe fittings; E, section of 90-degree long-turn Y branch or TY drainage fitting recessed and threaded for wrought pipe; note that the point Z is below the center line of the inlet pipe, an important feature in soil and waste lines; F, eighth or 45-degree bend, cast-iron, hub and spigot type; G, long-sweep quarter bend; H, sleeve, sometimes used for joining two spigot ends on repair work; I, long-sweep reducing quarter bend, 4-inch spigot, 3-inch hub, often used at the bottom of 3-inch soil stacks; J, offset; K, T-branch; L, T-branch tapped for wrought pipe; M, reducer; an increaser has the spigot on the smaller end; N, plug; O, sanitary T-branch; P, sanitary T-branch tapped for wrought pipe; Q, sanitary T-branch with right-hand side inlet; R, Y-branch; S, Y-branch with right-hand side inlet; T, combination Y and eighth bend or TY fitting; U, upright Y-branch.

varying from $\frac{1}{16}$ to $\frac{1}{2}$ of an inch may be used. Cement-lined pipe for underground work has had considerable local use for more than 50 years and has proved serviceable.

DRAINAGE AND VENT PIPES

House sewer.—The house sewer is usually vitrified clay or concrete sewer pipe 4, 5, or 6 inches in size, depending mainly on the fall. Full information on grading, laying, and jointing is given in Farmers' Bulletin No. 1227, Sewage and Sewerage of Farm Homes, which will be mailed free on request by the Department of Agriculture.

House drain and connections.—Within buildings all drain, soil, waste, and vent pipes, except short lead or brass connections to traps and water-closets, are generally iron or steel.

Cast-iron soil pipe.—Cast-iron soil pipe should be used underground. It is made in three thicknesses or weights—standard, medium, extra heavy. It is sold by the foot, inside diameter always being understood when referring to size. It has hub-and-spigot joints, comes in lengths to lay 5 feet, and is tested by manufacturers to 50 pounds per square inch. It comes plain or coated with tar or oil. Plain pipe is generally used above ground because defects are more readily seen. Coated, extra heavy pipe is generally used underground, being less subject to corrosion and more substantial. Table 3 gives data on cast-iron soil pipe.

TABLE 3.—Data on cast-iron soil pipe

[Single hub, 5-foot lengths]

Class	Inside diameter	Thick-ness of wall	Hub		Weight per length	Cost per foot ¹
			Inside diameter	Depth		
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	<i>Cents</i>
Standard.....	2	$\frac{1}{8}$	(2)	(2)	18	18
Do.....	3	$\frac{1}{8}$	(2)	(2)	26	24
Do.....	4	$\frac{1}{8}$	(2)	(2)	35	31
Do.....	5	$\frac{1}{8}$	(2)	(2)	45	39
Medium.....	2	$\frac{1}{16}$	(2)	(2)	20	19
Do.....	3	$\frac{1}{16}$	(2)	(2)	30	28
Do.....	4	$\frac{1}{16}$	(2)	(2)	45	37
Do.....	5	$\frac{1}{16}$	(2)	(2)	60	47
Extra heavy.....	2	$\frac{1}{4}$	$3\frac{1}{8}$	2 $\frac{1}{2}$	27 $\frac{1}{2}$	20
Do.....	3	$\frac{1}{4}$	$4\frac{1}{8}$	2 $\frac{1}{2}$	47 $\frac{1}{2}$	31
Do.....	4	$\frac{1}{4}$	$5\frac{1}{8}$	2 $\frac{1}{2}$	65	42
Do.....	5	$\frac{1}{4}$	$6\frac{1}{8}$	2 $\frac{1}{2}$	85	54

¹ Prevailing retail price, October, 1923.² Approximately same as for extra heavy pipe.

Standard pipe has considerable use on farms but due to its light weight is more apt to be broken during shipment, handling, cutting, and calking. Care is required to make an installation pass the usual tests, and the piping is easily broken by settlement or accident. As between standard and heavier, the saving in metal may not offset the disadvantages of the lighter pipe. Medium-weight pipe has considerable local use in some sections of the United States and is well adapted to farm use.

Cast-iron soil pipe has decided advantages in farm plumbing, especially for stacks. It is long-lived and great exactness is not required in planning and roughing-in the work. The pipe needs no reaming and is readily cut to make repairs or changes. The numerous joints take care of expansion and contraction, each permitting a little slip. A leaky joint, if accessible, is easily repaired with calking tools.

Wrought.—Wrought soil, waste, and vent pipes may be black or galvanized, the latter being most used. It should be standard weight as given in Table 2. Wrought pipe has these advantages over cast iron: It is lighter, stronger, more easily handled, and the joints are fewer, more easily made, and can not pull apart. When installed it is better looking, takes less space, and requires less support and less notching of joists and studs. The disadvantages are the difficulty in making repairs or changes and the shorter life of the pipe.

Brass.—Nickel-plated brass tubing is largely used for unconcealed wastes and vents (from fixture to floor or wall) and for closet flush

pipes. Thicknesses vary from 1/50 to 1/25 of an inch, the thicker being preferable.

Lead.—Lead waste and vent pipe should be about $\frac{1}{8}$ inch thick and weigh per running foot as follows: $1\frac{1}{4}$ -inch, $2\frac{1}{2}$ pounds; $1\frac{1}{2}$ -inch, 3 pounds; 2-inch, 4 pounds; $2\frac{1}{2}$ -inch, 5 pounds; 3-inch, 6 pounds; 4-inch, 8 pounds. Where plumbers are available, lead pipe is still used extensively, being smooth, lasting, pliable, and easily worked. However, it must be well supported to prevent sag, it is easily punctured by nails, is sometimes gnawed by rats, and care is necessary to produce soldered or wiped joints of smooth bore.

CORROSION AND LIFE OF PIPE

Pipe and fittings are made with greater thickness than that required to sustain the water pressure. This is to guard against corrosion and the strains caused by cutting, threading, and joining pipes and expansion and contraction of pipe lines. All waters and soils corrode, the action being more noticeable at joints and in iron or steel pipe of poor quality. Acid or alkaline water or soil corrodes pipe faster than neutral; soft water faster than hard; ground water faster than surface; hot water faster than cold; wet soil faster than dry; salt, clay, or cinder soil faster than sands or gravels; polluted soil faster than clean; foul air faster than pure; a large flow faster than a small; high pressure faster than low. Steel and wrought iron are corroded faster than cast iron, brass, or lead; horizontal lines faster than vertical. Electrolysis and local galvanic action increase corrosion, hence the importance of not grounding telephone and other electric lines to plumbing and of using pipe and fittings of like composition.

Under average conditions small black wrought pipe in the ground should last 10 to 20 years; galvanized steel, 15 to 30 years; galvanized wrought iron, 20 to 40 years; lead and cast iron, 40 to 75 years. It is, however, not uncommon to find lead and cast-iron pipes sound after 80 to 100 years, and, except for slight external corrosion, cement-lined black wrought-iron pipe has been found in perfect condition after 40 years in the ground. Steel pipe coated inside and outside with 1:1 cement mortar has been found intact after 60 years.

Water containing much hydrogen sulphide, carbonic acid, or oxygen may dissolve galvanizing in a few months. Wiped joints in lead pipe have become porous and leaky in a few years. Steel pipe has become worthless in 5 years, wrought iron in 10 years, and cast iron in 15 years. But such instances are exceptional.

Within buildings hot-water pipes usually fail first; sometimes horizontal runs fail or clog within 10 years. Cold water, drainage, and vent pipes should last as long as the average farm building.

PIPE SIZES

Water pipe.—Pipe sizes are governed by the available pressure and the desired rate of delivery. Larger pipes are now used than formerly, the reasons being greater delivery, less clogging, less robbery by other faucets used at the same time, slower velocity and less hissing noise, longer life of the pipe, and cleaner wastes and drains. Medium pressure is better than high, lessening waste of water, wear

and tear of plumbing, and air bubbles in the water. Where the pressure exceeds 80 pounds per square inch a pressure regulator should be placed near the cellar wall and on the house side of the branch to the sill cock, leaving full head on that fixture.

A reasonable service in an ordinary home requires discharges not less than the following:

	Gallons per minute
Kitchen sink, 1 faucet_____	3
Kitchen sink, 2 faucets_____	5
Laundry tub, 2 faucets_____	5½
Sill cock_____	5½
Bathroom_____	10

All of these fixtures are seldom used at one time. On average days the maximum draft of a family of six is about 10 or 12 gallons per minute for short periods, but frequently fixtures are used in such combinations as to increase the draft to 18 gallons per minute. Larger establishments cause larger maximum drafts, but seldom is the increase at all proportional to the figure given above for six persons.

A $\frac{1}{2}$ -inch kitchen faucet (inlet 0.53 inch and outlet 0.48 inch) tapped into the side of a barrel of water 2.3 feet from the top is under a head of 1 pound, and discharges, when fully opened, 3 gallons per minute; a $\frac{5}{8}$ or $\frac{3}{4}$ inch faucet does very little better. If the faucet were at a distance from the barrel, the discharge would be less, but could be made to equal that stated by using either a higher barrel or larger pipe.

The smallest pipe to lay from a spring, tank, or reservoir to a house is the one that will deliver the probable maximum draft to the central point of use and still leave 1 or 2 pounds head on the highest faucet. That central point is usually the bathroom or kitchen sink, and the size of the house-supply pipe should be determined with that in mind. The problem can be easily solved by the use of the diagram and directions in Figure 7.

Poor service is often due to the use of small leading pipes within the house. Such situations are not greatly improved by large faucets and fixture pipes which add to the cost and make the plumbing clumsy. From house supply to bathroom, there should be little reducing of size. Table 4 indicates suitable sizes for branch and fixture pipes when supply pipes are of the sizes shown. The smallest size of fixture pipe indicates the size of faucet, except that $\frac{3}{4}$ -inch pipe may have a $\frac{1}{2}$ -inch faucet, and high-pressure wash-basin connections of brass may reduce in the last few inches to take $\frac{1}{4}$ -inch faucets.

TABLE 4.—Size of water pipes (inches)

Class of pressure	House supply	Bath-room	Bath-tub	Washstand		Closet tank		Kitchen sink	Laundry	Sill cock
				Pipe concealed	Pipe exposed	Pipe concealed	Pipe exposed			
High	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Medium	$\frac{1}{2}$ or $\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Low	$\frac{1}{2}$ or $\frac{3}{4}$	$\frac{3}{8}$ or $\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$

The above classification of pressure is merely suggestive. Pipe lengths and the number and character of fixtures must always be considered. For example, a distant watering trough having a float-controlled valve may be well served with $\frac{1}{2}$ -inch pipe; with an ordinary faucet a $\frac{3}{4}$ -inch pipe may be necessary. A spray head may be well served with $\frac{1}{2}$ -inch pipe, whereas a large shower bath or a long run may require $\frac{3}{4}$ -inch pipe. In general, branch runs longer than 25 feet or supplying two or more small fixtures should be $\frac{3}{4}$ -inch pipe. An ordinary house supplied from an attic tank should use pipes not smaller than those of the last line in Table 4; to the bathroom $1\frac{1}{4}$ -inch pipe would be still better.

Drainage and vent pipes.—Safe sizes of soil, waste, flush, and vent pipes are shown in Table 5.

TABLE 5.—Size of soil, waste, flush, and vent pipes

Pipe and condition	Size
	<i>Inches</i>
House drain—ordinary house, no rainwater	4
Soil stack	3
Water-closet bend and branch to soil stack	3 or 4
Water-closet flush, low tank, O. D. tubing	2
Waste—concealed, pitched, or vertical:	
Slop sink or large shower bath, each	2
Kitchen sink, one laundry tub, shower head, bathtub, washstand or similar, small fixture, each	$1\frac{1}{2}$
Two small fixtures	$1\frac{1}{2}$
Three to five small fixtures	2
Slop sink, kitchen sink, or floor drain buried in ground or concrete	3
Waste—exposed, pitched or vertical; O. D. tubing:	
Kitchen sink, or 1, 2, or 3 section laundry tub or combination sink and 1 or 2 section laundry tub with continuous waste and trap	$1\frac{1}{2}$
Bathtub, O. D. tubing	$1\frac{3}{8}$ or $1\frac{1}{2}$
Washstand, O. D. tubing	$1\frac{1}{8}$ or $1\frac{1}{2}$
Traps—no smaller than entering waste; minimum seal, 2 inches.	
Vents—Extension of soil stack	3
One to five small fixtures	$1\frac{1}{2}$
Water-closet (if another is above), either with or without the usual small fixtures	$1\frac{3}{8}$

¹ The larger size is preferable.

FITTINGS

Figure 8 shows the principal fittings. They should be of similar metal and thickness as the pipe. Sizes refer to the nominal inside diameter of the connecting pipes, the run being given first and the branch last. For example, the tee, $\frac{3}{4}$  $\frac{3}{4}$ is read $\frac{3}{4}$ by $\frac{3}{4}$ by $\frac{1}{2}$, or shortened to $\frac{3}{4}$ by $\frac{1}{2}$ T.

Fittings for wrought water pipe should be galvanized or lined like the pipe itself. Plain galvanized malleable iron fittings are suitable for low-pressure indoor pipes but the stronger beaded fittings should be used for higher pressures and underground work.

Drainage fittings for wrought pipe have enlarged ends forming a recess about $\frac{3}{4}$ inch deep. The fittings have the same bore as standard pipe which, when screwed in, butts against the shoulder, forming a smooth continuous waterway. Long sweep elbows and TY fittings should be used on all drainage lines. Square elbows and T and TY branches are tapped about 5 threads, pitching the inlet pipe $\frac{1}{4}$ inch per foot. Ordinary beaded fittings are used on vents.

JOINTS AND CONNECTIONS

Joints require special care since they are the weakest parts. Hub and spigot joints are made by ramming with a yarning iron a twisted strand of oakum or jute into the bottom of the joint space, filling at one pouring with molten pig lead, and driving with hammer and calking tools. Oakum or jute is used in cast-iron soil pipe, leaving about 1 inch for lead, $\frac{1}{2}$ to $\frac{3}{4}$ of a pound of which is required per inch of pipe bore. Jute is used in cast-iron water pipe, leaving about 2 inches for lead, about $1\frac{3}{4}$ pounds of which are required per inch of pipe bore. Using a calking tool pointed about $\frac{3}{16}$ by $\frac{3}{4}$ inch, the joint is gently driven all around several times. This avoids splitting the hub and evenly compacts the lead. The next driving is harder and the joint is smoothly finished with the calking tool that most nearly fits the space without binding. It is sometimes very convenient to use lead wool in loose rope form, calked cold, instead of molten pig lead.



FIG. 9.—Cutting cast-iron soil pipe with a cold chisel



FIG. 10.—Use of a yarning iron to pack a strand of oakum or jute into the bottom of the joint space

Cast-iron pipe is cut with a wheel pipe cutter or a cold chisel, the latter requiring more care and labor. To cut standard cast-iron soil pipe with a cold chisel, first cut or groove the pipe squarely around with a three-cornered file. The pipe, at the groove, is rolled on a piece of 2 by 4 laid flat and the cold chisel lightly tapped to circle the pipe several times. Heavy pipe may be grooved or impressed with the cold chisel and heavier blows may be struck. If the groove is formed squarely around the pipe, an even break usually occurs after circling two or three times. Figures 9, 10, 11, 12, and 13 show the methods above described.

Wrought pipe is cut with a hack saw or a wheel or knife pipe cutter, twisting the handle an eighth to quarter turn to the right each time around the pipe. If the cutter is too tightly set, the wheels cause a deep burr in the pipe bore. It is especially important in water and drainage piping that the burr be removed with a reamer.

Threads are cut with a steel die held in a stock carrying a guide with bushings adapted to different sizes of pipe. The guide and bushings prevent cutting crooked threads. Dies are marked with the size of pipe they thread. The mark must face the operator, who

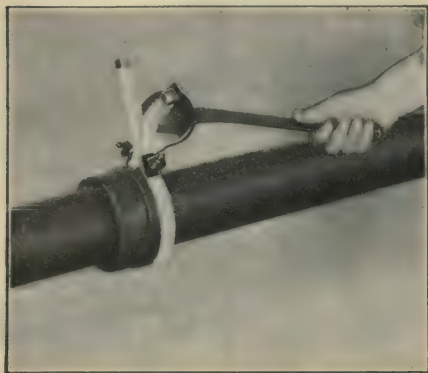


FIG. 11.—Horizontal pipe line—use of an asbestos pipe jointer clamped at the top and firmly pressed against the hub to prevent escape of the molted lead

rotates the stock clockwise, the direction of making up all right-hand threads. The die should be sharp; if dull or broken the thread and joint are likely to be defective. To make the die take hold of the pipe and not strip it, the end should be free of oil and the stock must be pushed hard. As soon as the die catches, plenty of good lard oil or crude cottonseed oil should be applied to the cutting, otherwise the thread will be poor and the die may be spoiled. The stock is turned until the end of the pipe is about flush with the face of the die.

Further threading is not only

useless but may be a hindrance to making up tight joints. Solid dies for $\frac{1}{2}$ to $1\frac{1}{2}$ inch pipe are $\frac{3}{4}$ inch thick, being a little less for very small pipes and more for large ones. Thus seven or eight effective, taper threads are cut and about half of these may be run by hand into a fitting or valve. Tightness is secured by turning the last three or four threads with a pipe wrench. Graphite or red lead and linseed oil is used on the male (pipe) thread to lessen friction and promote tightness of the joint. There should be few or no threads outside the fitting because their presence weakens the pipe and favors early corrosion and leakage. Such threads may be painted with black asphaltum to lessen corrosion, but it is better to use an adjustable die which permits cutting a thread to screw completely into the fitting. The methods above described are shown in Figures 14, 15, and 16.

Figure 17 shows a few special joints. Figure 18 shows water-closet connections in common use. The flanged lead and putty joint is very simple, but is prohibited by many local ordinances. Figure 19 shows how the lead bend is beaten out flat with a hammer. The flattened end and the entire bottom of the bowl are smeared with red lead. About 2 pounds of putty are spread over the bottom of the bowl,



FIG. 12.—Vertical pipe line—pouring melted pig lead into a hub to fill the joint space

using care to more than fill the circular groove around the horn. The bowl is then set in position and heavily pressed, first on one side and then on the other, to obtain a full, even bed of putty under the whole bottom. The bowl is then tightly screwed to the floor. Figure 20 shows a cast-iron flange flat on the floor and in correct position for inserting the brass bolts, placing the gasket or putty, and screwing down the nuts to hold the bowl.

LOCATION OF PLUMBING

A plan or sketch showing pipe sizes and locations and general arrangement of fixtures should always be made before spending a penny. Simple houses make for simple, easily installed plumbing, as illustrated in Figure 5. Laundry, kitchen, and bathroom are over one another, lessening piping and making it direct and compact. Other

reasons for having the bathroom over or near the kitchen are that with this arrangement there is less chance for freezing and less objection to leaks or noise from bathroom fixtures. Every bathroom should have a window, skylight, or ventilating duct to the outer air.

With respect to bathroom fixtures, the best location of the soil stack is back of the water-closet or a little toward the washstand, as shown in Figure 5. Placing the fixtures along one wall saves pipe. Figure 21 shows the position of the fixtures in six bathrooms and what may be accomplished in small and medium areas. Figure 22 shows how attractive the interior of a 5-foot square bathroom may be made.

The kitchen sink should be located to insure light, air, and fewest steps. It should be located so that a drain board at both ends is possible, as shown in Figure 4. It should be close to the cupboard, thus saving

steps and a second handling of the wiped dishes. It should be near the pantry and not so close to the kitchen range as to cause discomfort. Nearness to the soil stack means less piping. Plumbing



FIG. 13.—Calking a lead joint to make it air-tight and water-tight



FIG. 14.—Cutting wrought pipe

should be safe from frost. No unprotected pipes should be placed in outer walls of poorly heated houses in cold climates. No pipes should be embedded in masonry; a recess or channel may be left or the piping placed in partitions as in frame buildings. Often where it is not feasible to carry piping in partitions, the stacks are run through niches or closets, placed in a box with removable panels, or left exposed.

ROUGHING-IN

In new houses the pipes that will be concealed should go in after the framing is erected. In old houses it is equally important to know how pipes must run to meet fixture openings. Roughing-in is the installing of the pipes to floor and wall lines. Manufacturers of fixtures and connections prepare roughing-in measurements of their products. There are no fixed standards, though the variations among manufacturers are small. When the

householder decides on his fixtures, he should obtain the roughing-in measurements for those particular fixtures. Figure 23 shows typical roughing-in measurements of a sink and a water-closet.

Sinks and laundry tubs are set higher than formerly, 30 to 31 inches from the bottom of the sink to the floor is considered a good average height (see fig. 29). For the average worker the top rim of the tub should be about 36 inches from the floor; in all cases the tub should be placed so that the worker does not stoop from the shoulders but bends at the hips.

The house drain is generally installed first and the soil stack is carried upward from it. The fittings for branches should be assembled in correct position and the length of the pipe to be cut to fit should be measured with a tape or stick. The work should proceed step by step. After one piece of pipe with fitting permanently attached is

in place, measurement should be made to reach the next fitting. The procedure for water pipes should be similar. Methods of supporting and roughing-in pipes are shown in Figures 24, 25, 26,



FIG. 15.—Threading wrought pipe—position of the operator when pushing the stock and die to start the thread



FIG. 16.—Threading wrought pipe—after one or two threads are cut, pushing is unnecessary and the operator may turn the stock as above indicated

27, and 28. All piping (except traps) should grade to drain back to the cellar, water pipes wasting at the stop and waste just inside the cellar wall, and soil, waste, and vent pipes bleeding into the house drain. For soil and waste lines, the slopes per foot should not be less than $\frac{1}{4}$ inch; for vents, $\frac{1}{8}$ inch; for water pipes, $\frac{1}{10}$ inch. There should be no sags or pockets in which water can stand and freeze.

FIXTURES

The most popular sinks, bathtubs, and washstands are enameled cast iron (white glassy coating fused on a thin cast-iron shell). Closet bowls and tanks are generally vitreous ware (fused China clay) $\frac{1}{2}$ to $\frac{3}{4}$ inch thick; the material closely resembles ordinary white table crockery. Solid porcelain, so called, sometimes used

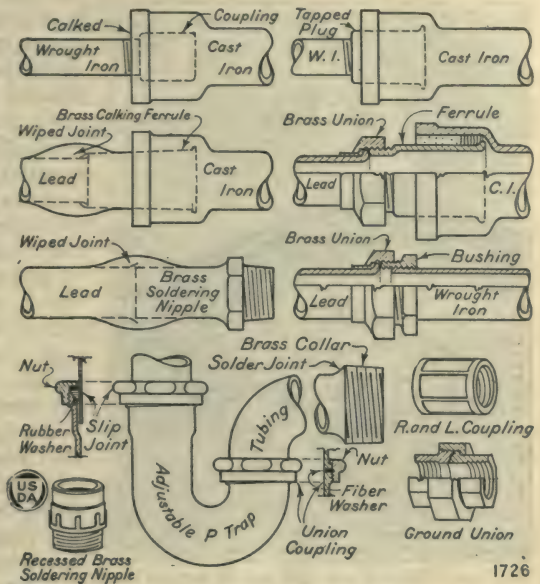


FIG. 17.—Methods of joining different kinds of pipe. The right and left coupling and ground union are used to join threaded male ends on water and vent pipes. To connect two pipes with a right and left coupling, tightly screw the coupling on the right-hand thread and mark the distance with chalk; take off the coupling and count the threads covered; screw the coupling on the left-hand thread and count the threads covered; screw the coupling on the pipe end having the greater number of threads until an equal number of threads is exposed on both pipe ends; engage the free end, turn the coupling and both ends will tighten equally.

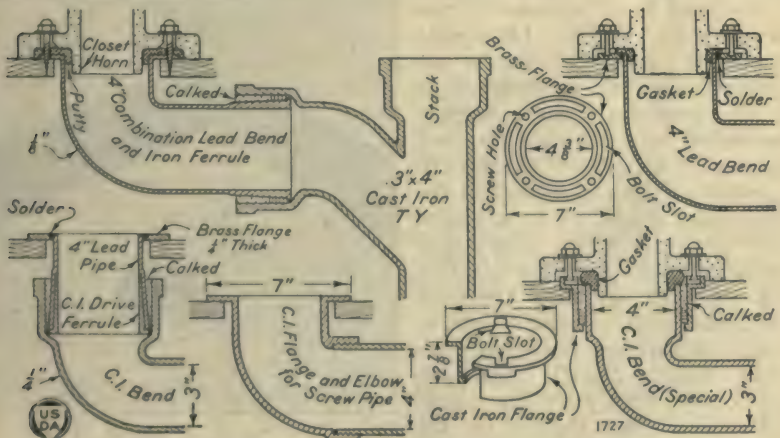


FIG. 18.—Methods of making water-closet connections

for sinks, laundry, and bath tubs, is very different from vitreous ware. The material beneath the glazing is more absorbent, fixture walls are

$1\frac{1}{2}$ to 2 inches thick, and the fixtures are heavy and costly; like all earthenware they must be handled and installed with great care. The number, size, and character of the fixtures should always be in keeping with the surroundings and the pocketbook; simple, unornamented white fixtures are best. Generally, the prices quoted are close, retail, cash figures and do not include freight. The cost of plumbing fixtures, like many other products, has a wide range with differences in design, materials, durability, and finish. Size refers to the overall (outside) width and length.



FIG. 19.—Beating out the end of a lead bend to form a flange

Sinks.—Sinks come in plain and enameled cast-iron, painted, galvanized, and enameled steel, soapstone, slate, glazed fire clay, and vitreous ware. A fair size is 20 by 30 or 36 inches. Steel and flat-rim iron sinks are supported by iron, steel, or

other heavy sinks are supported by brass wall brackets. Stone and frames or by legs and wall fastenings. The fastenings for stone and apron sinks may be iron or brass angles screwed or bolted to wall and fixture, but generally the leg is braced direct to the wall by a horizontal iron strap with angle. One-piece enameled sinks with backs are fastened by two or more lugs in the rear top which engage concealed iron hangers screwed through to the studs, to “grounds” firmly nailed in between the studs, or to a board screwed to the studs. The board should be flush with the plastering. Expansion bolts are used in brick and concrete walls; toggle or through bolts in terracotta walls. Small sinks are supported wholly by the hangers. Sink tops should be set level, the same as other fixtures.

The best sinks are enameled, roll-rim, or apron, with 12-inch high integral back hollowed for supply pipes, and one or two drain boards

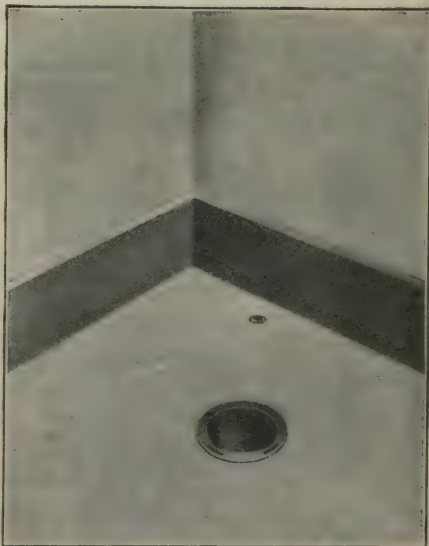


FIG. 20.—Cast-iron flange in position for fastening the bowl

similar to that shown in Figure 29. This sink has adjustable legs, which permit varying the height from the floor, and combination swing faucet, which permits drawing hot, cold, or tempered water and aids in rinsing and filling dishes. It is well to use a hardwood mat to protect the sink bottom.

Sinks 20 by 30 inches, without trimmings, cost approximately as follows: Flat rim, cast iron, painted inside and out, \$4; steel or cast iron, enameled inside, painted outside, \$6 to \$9; enameled, roll rim, integral back, \$14.25; soapstone, \$16.35; slate, \$17.55.

Laundry tubs.—Laundry tubs are made of artificial stone and of similar materials as sinks. White or light shades are best, because

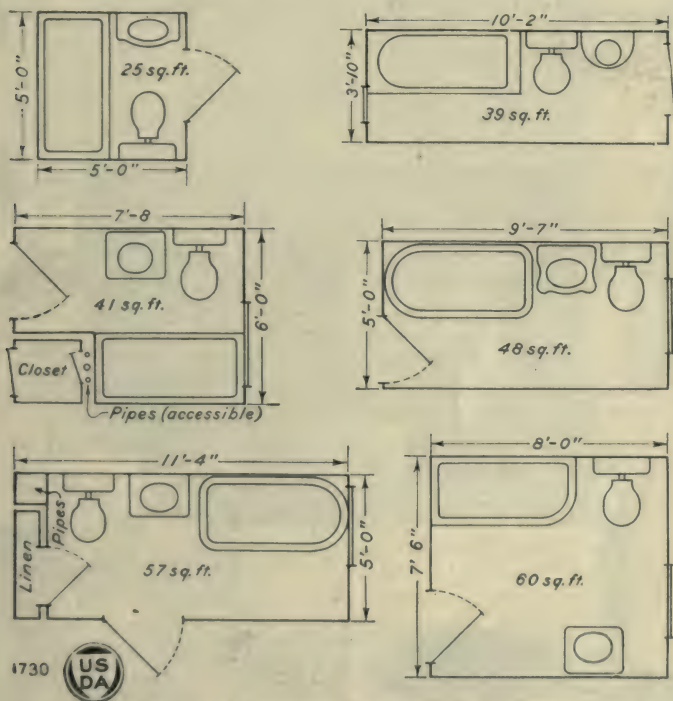


FIG. 21.—Floor plan of six typical bathrooms

dirt, either on the clothes or the tub, is more readily seen. A plain, two-section artificial stone tub 24 by 48 by 15½ inches with legs costs \$14.60; the same with 6-inch high back, \$20; soapstone and slate, \$20 to \$25. A stub compression faucet costs 75 cents. A double laundry faucet with swing spout is very handy for two-section tubs and costs \$3.50.

Bathtubs.—A fair-size bathtub is 30 by 60 inches. A 3-inch roll rim, enameled inside, painted outside, width and length over rim as above, 22 inches high on feet, costs \$28 to \$43; for usual trimmings add \$8 to \$10. A built-in corner pattern tub 30 by 60 by 17 inches, enameled inside and outside, tiling about one-half inch into floor and two walls, costs with trimmings \$65 to \$93. A 5-foot enameled tub,

recess pattern, concealed pipes (see fig. 22) costs with trimmings \$85 to \$108. Tubs of the last two types prevent dirt from collecting under or back of them, and lighten the work of cleaning the bathroom. Tenant farmers whose stay on a given farm is of indefinite



FIG. 22.—Attractive bathroom interior, 5 feet square

length may find a portable galvanized steel bathtub and water heater a great convenience.

Washstands.—A fair size washstand is 18 by 24 or 20 by 24 inches with 12 by 16 inch bowl. Corner stands are sometimes used, a fair

size being 19 by 19 inches on each wall, with bowl 11 by 14 inches. Washstands are supported like sinks; those with flat top stand out $1\frac{1}{2}$ inches from the wall and have wall brackets, concealed supports, or a leg or pedestal and braces to the wall; those having integral slab, back, and bowl are supported by a concealed hanger, by wall brackets, or by a leg and brass wall clamps. A half-circle, roll-rim, enameled one-piece washstand 17 by 19 inches, 6 inch-high back, with trimmings to wall, costs \$13 to \$20. A square enameled one-piece apron washstand 18 by 24 inches (a popular size), 10 inch-high back, with trimmings to wall, costs \$20 to \$29. The top is of good shape and size to set toilet articles during their use.

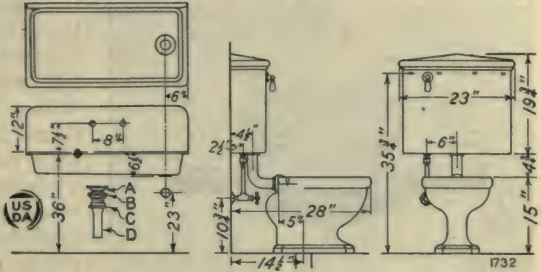


FIG. 23.—Typical roughing-in measurements of a flat-rim kitchen sink with detachable back and a reversed-trap, siphon-action water-closet; the distances are not fixed standards but are merely illustrative of particular types of fixtures from one manufacturer. A, detail of strainer piece; B, lock nut and washer; C, coupling nut; D, tail piece; the strainer has nineteen $\frac{1}{4}$ -inch holes and may be easily detached when it is desired to use a rubber stopper in the sink outlet

Water-closets.—Water-closet bowls are generally vitreous ware, with trap formed inside and the flush siphoned downward through the floor. The area and depth of standing water should be large; the dry surface that can soil should be small. Figure 30 shows sections of typical siphon-action and siphon-jet bowls.

Ordinary siphon-action bowls (see fig. 22) have the long, curved-out leg in front; they give good service and cost less than the other types. Reversed-trap siphon-action and siphon-jet bowls have the long leg in the rear, improving their appearance; the operation of both types is quieter and stronger than in the ordinary siphon-action bowl. Siphon-jet bowls are readily recognized by the jet opening in the inside bottom of the trap and by the two rear outside swellings over the passage to the jet.



FIG. 24.—Cast-iron pipe rest notched into two floor joists

The flush tank is usually vitreous ware, but enameled iron, and wood lined with copper, lead, or zinc are used also. Vitreous and wood tanks are supported by brackets or by two $1\frac{1}{2}$ by $1\frac{1}{2}$ by $\frac{3}{4}$ inch wide steel or cast-brass angles at the bottom and by two or three $\frac{1}{4}$ -inch iron hooks, lag screws, or bolts through holes in the top of the back. All fastenings must go into solid support. Enameled tanks have wall hangers and support-

ing lugs on the back as shown in Figure 31. A fair size tank is 18 or 19 inches long, 6 inches wide, and 16 inches high inside; the flushing depth is 9 to 10 inches and the flush is 4 to 5 gallons. The flush should occur in 7 to 10 seconds, the shorter

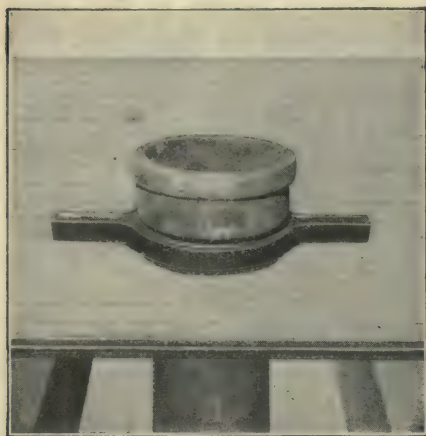


FIG. 25.—Cast-iron pipe rest on the top of a floor

time being best. If the valve does not rise sufficiently from the seat to flush quickly the trouble is easily overcome by shortening the loop of the long lift wire shown in Figure 31. When in good working order there is little rise of water in the bowl. A siphon-action vitreous bowl with white wooden seat and vitreous tank complete costs \$29 to \$49; the same outfit, except with siphon-jet bowl, costs \$36 to \$69; an oak tank costs \$10 to \$11, and enameled and vitreous tanks \$14 to \$16.

risers from and drops into a hollowed seat. Most valves give more or less trouble with age because the ball gets out of shape and fails to seat properly; or because slime and wear of the working parts or failure of the lift wire

to work straight up and down in the guide holder causes the ball to stick and remain up when it should drop to its seat. Another type of valve consists of a thin flat disk with leather seating washer. The float is generally a hollow copper or glass ball about 5 inches in diameter. Glass floats are of more recent introduction and, being noncorrosive, are very desirable but are more liable to be broken. Most of the tank mechanism is under water and deteriorates rapidly; it gets considerable rough use and little or no attention until out of order. Worn-out rubber balls and leaky water-logged floats should be promptly replaced with new ones; the cost is small. The handle and lever mechanism should be simple and easily operated; the guide holder should be adjusted to keep the lift wire plumb.

The most widely used flushing valve is a $2\frac{1}{2}$ -inch rubber or copper and rubber ball which

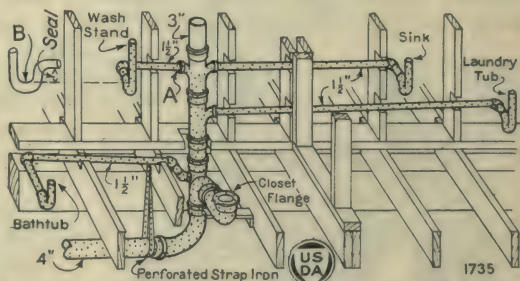


FIG. 26.—Supporting and roughing-in a simple, one-pipe system—a very economical method for bungalows and cottages with fixtures on one floor and near the soil stack. Note three points: (1) There are no back vents; (2) all small waste pipes enter the stack above the closet branch, thus preventing the water-closet from siphoning the small traps; (3) in no instance is the inside bottom of the waste pipe at the stack (point A) lower than the dip of the trap (point B), thus preventing self-siphonage of the trap; this provision limits the length of the waste; for example if the trap seal is 2 inches and the slope of the waste is $\frac{1}{4}$ inch per foot, its length should not exceed 8 feet (2 divided by $\frac{1}{4}$ equals 8) and less would be better.

A seat-operated, inside enameled closet for outhouses and other freezing situations is shown in Figure 32 and costs \$18.

Shower baths.—Many homemade shower heads are failures because they are made of corrosive metal with too many large holes. A small head with $\frac{3}{32}$ -inch holes (about the size of a medium pin) saves water and adds to the force and effectiveness of the shower. A nickel-plated brass head with pipe and wall bracket support and rubber tube to fit any ordinary double bathtub faucet costs \$4; the same with 24-inch nickel-plated curtain ring and curtain costs \$9 to \$10. At greater cost a shower may be permanently connected with the bathtub supply or with visible or concealed wall pipes having a hot and cold control valve within a stall or receptor with trapped floor drain.

HOT WATER

Hot water is necessary in every home. Pipes must be under pressure and there must be a heater—coal, wood, kerosene, gasoline, natural or artificial gas, or electric. There is usually a hot-water storage boiler or tank. The operating principle is that hot water is lighter than cold water and rises; the cold water sinks to occupy its place, thus creating circulation. The secret of success is to connect and pitch the pipes to make the circulation sure and easy. Humps or air pockets must be avoided.

The device most used for heating water is a hollow iron casting lining one or more sides of the fire box in the kitchen range. Western people call it a water front; eastern people call it a water back. The ordinary straight water back is brick shaped, has walls about $\frac{1}{2}$ inch thick with two tappings for $\frac{3}{4}$ or 1 inch pipe, and is tested to 250 pounds per square inch; its usual position is in the left side of the firebox opposite the oven. For large supplies L or U shaped

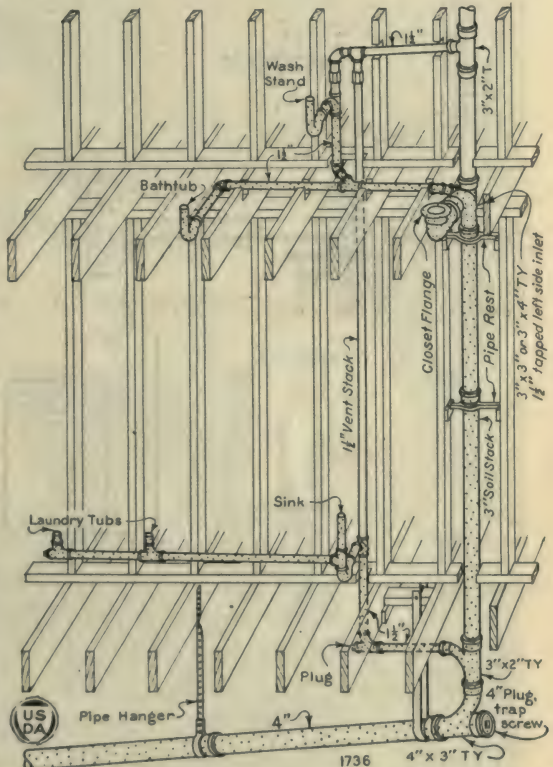


FIG. 27.—Supporting and roughing-in a simple two-pipe system having continuous wastes and vents; the most effective way of venting traps. Drainage pipes are stippled and vent pipes are outlined

backs are used. Instead of a water back, a coil of two or four pieces of black wrought pipe joined by return bends is sometimes installed in the left side of the firebox. The capacities of water back and

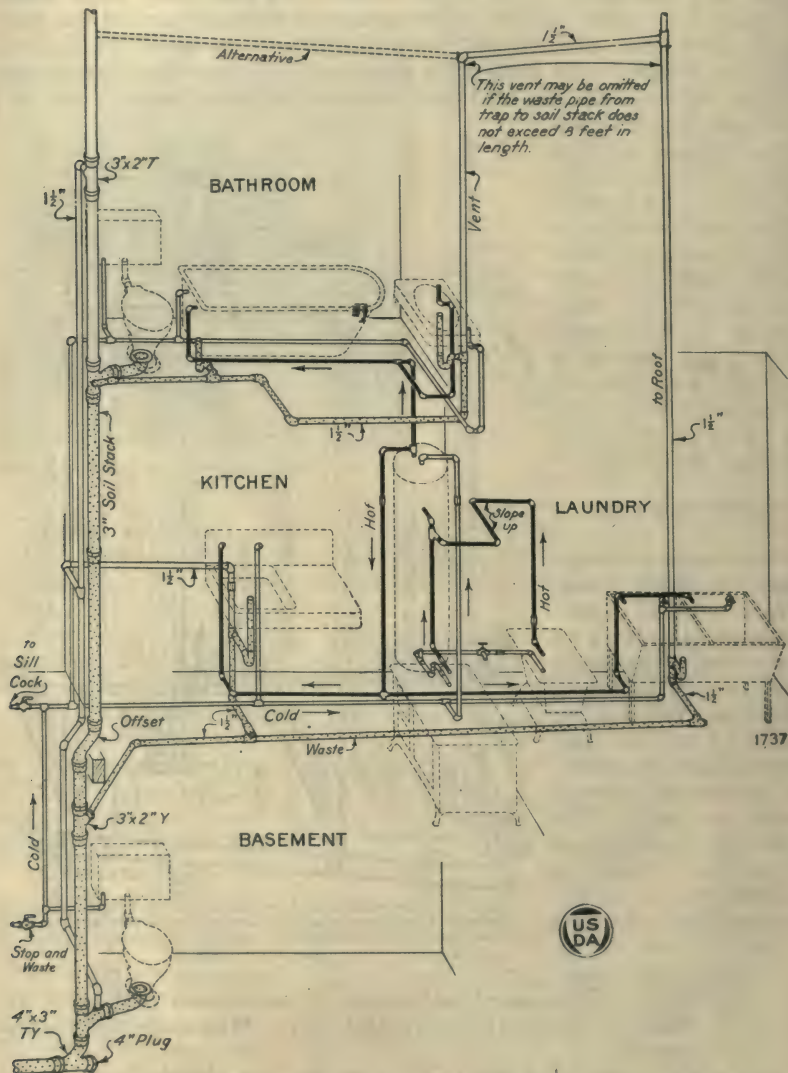


FIG. 28.—Roughing-in the drainage and water pipes for a two-story house with water-closet in the basement and laundry in a rear room. Drainage pipes are stippled, hot-water pipes are in black and cold water and vent pipes are outlined

boiler should be in proportion, both conforming to the hot-water requirements. A small water back and large boiler give insufficient hot water; a large water back and small boiler give overheated water with, perhaps, snapping, cracking, or rumbling noises.

Where an ordinary family uses hot water in small, frequent quantities a 30-gallon boiler is satisfactory; large, infrequent drafts require greater storage. Straight water backs for 30-gallon boilers vary from 13 by $4\frac{1}{2}$ by $1\frac{1}{2}$ inches to $13\frac{1}{2}$ by 7 by 2 inches, but on the average the heating surface is about $\frac{1}{2}$ square foot or $2\frac{1}{2}$ square



FIG. 29.—An enameled-iron apron sink with integral back and combination swing faucet. Every housewife should determine by experiment how high her sink should be set to give an easy, erect, working position; for a woman of average stature a favorable height to the top of the apron or rim is 36 inches (yard-stick high)

inches per gallon of boiler capacity. For a 40-gallon boiler the heating surface of the water back should approximate 100 square inches; for a 50-gallon boiler, 125 square inches. Under favorable conditions a good fire with a $\frac{1}{2}$ square foot water back and 30-gallon boiler will furnish 15 gallons of water per hour warmed from 60° F. to an average of 120° F.; under like conditions a fire for baking or roasting will furnish 20 gallons per hour. This is sufficient to give hourly 30 gallons of water tempered for bathing to approxi-

mately 100° F.; or to give all reasonable quantities of hotter water for dish washing and like uses.

Range boilers are made of copper or steel and in thicknesses or strengths to conform with the water pressure. If a boiler is supplied from an attic tank equipped with a ball cock, it may be light weight; for direct pressure it should be heavier. The tank system is less



FIG. 30.—Sections of typical siphon action and siphon jet water-closets

age through the house service pipe. Another strong merit is the ready means of providing for expansion of the heated water and escape of air therefrom. This is done by running the hot-water pipe from the top of the boiler up and over the top edge of the tank. Copper boilers are generally tin lined and steel boilers are galvanized

inside and outside. The former are best because they impart no rust to the water, last longer, and look better.

The boilers are usually set vertically and close to the range. Sometimes they are

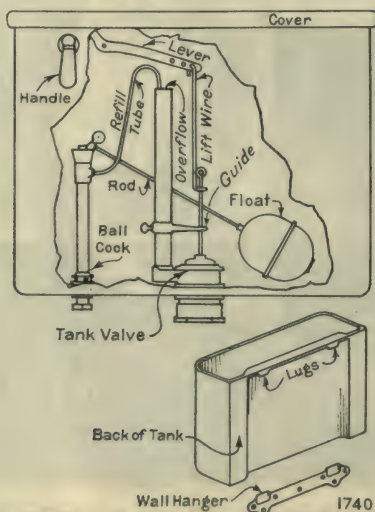


FIG. 31.—An enameled-iron flush tank with front wall cut away to show the essential working parts; below is shown the back of the tank with the lugs which engage the concealed wall hanger

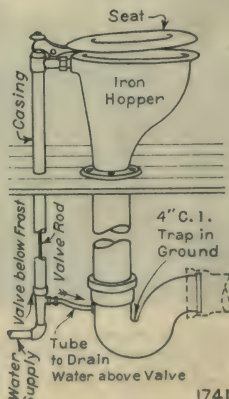


FIG. 32.—An antifreezing water-closet

concealed in a small wall closet adjacent to the chimney or placed in a bathroom not otherwise heated. A cellar location with heater above is undesirable because hot water does not readily circulate downward. A standard-weight, galvanized steel boiler 12 by 60 inches, 30 gallons capacity, costs about \$12 and is suitable for 85 pounds working pressure; the same size in copper costs \$25 to \$45.

Galvanized boilers usually have five 1-inch tappings, two in the top, one in the bottom, and two in the side. The pipes between the boiler and water back are generally $\frac{3}{4}$ inch, the connections being made with 1-inch bushings or boiler couplings. Copper boilers usually come with couplings inserted and with male thread for $\frac{3}{4}$ -inch pipe. Figure 33 shows four ways of connecting range boilers and water backs; the advantages of each method are indicated in the notation. To prevent mixing the cold and hot water, the cold-water pipe is extended inside the boiler as shown. This inner pipe is generally $\frac{3}{4}$ inch, should have a $\frac{1}{8}$ -inch air hole tapped near its top to prevent siphonage, and should end at the level of the top of the water

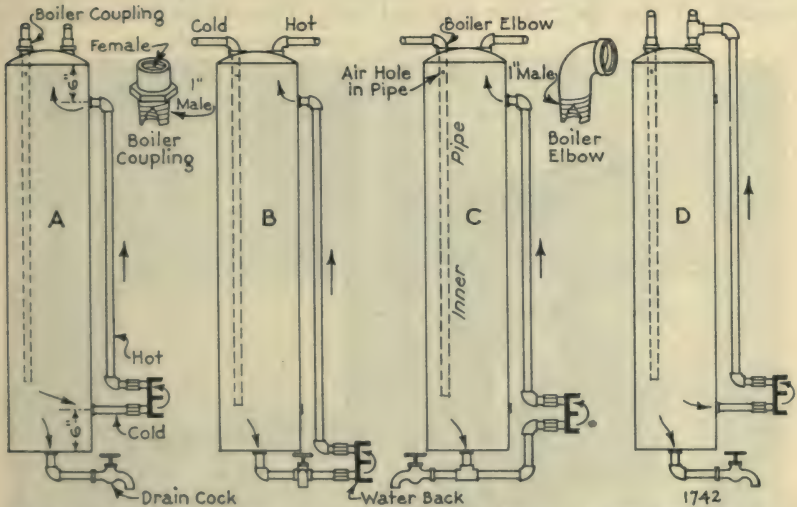


FIG. 33.—Four ways of connecting range boilers and water backs. The pipes are generally $\frac{3}{4}$ inch and preferably of brass. Arrows show the direction water moves. A. Standard tappings; short, direct connections; excellent for either water back or gas heater; gives several gallons of hot water in a short time; has ample space in which sediment may settle below the line of circulation; occasionally a pall of water should be drawn off at the drain cock. B. Cold-water flow pipe from bottom of boiler. C. A common method where the height of the boiler stand does not permit the straight connection shown in A and B. D. Connection just above the boiler; often used with a gas heater because small quantities of hot water can be drawn in a minute or two after lighting the gas; this connection is not as reliable as A, B, and C for the reason that if not properly made, cold water may short circuit through the heater and be drawn at hot-water faucets.

back. It should be brass or copper pipe or heavy tubing, thus preventing rusting off or closure with rust; it is readily inserted in the boiler by means of a boiler coupling or boiler elbow having a 1-inch male thread and two $\frac{3}{4}$ -inch female threads. Where the pressure is high, permitting small pipes, the two female threads may be $\frac{1}{2}$ inch.

Figure 34 shows a simple, serviceable, homemade installation in a dairy wash room at Milo, Me. Figure 35 shows how the foregoing installation could be improved, utilizing either a wooden or steel barrel, force pump, and kitchen range. Figure 36 shows a boiler connected to a range and a laundry stove, thus making use of either or both sources of heat. Figure 37 shows a similar arrangement with a range, a gas heater, and a coil in the furnace.

To get warm water quickly where faucets are far from the boiler the hot-water line may loop back from the farthest fixture branch and be returned into the cold-water flow pipe from the bottom of the boiler to the water back (or furnace). Thus warm water constantly circulates through the boiler and past fixture branches. The system is suitable for large establishments, but the heat lost by radiation in a long circuit makes it uneconomical. If used, the circulation pipe and the boiler should have an insulating covering, and the return pipe should have a light swing check valve set 45° to the horizontal to prevent cold water moving from the bottom of the boiler through the return when a faucet is opened.

Caution: Serious range-boiler explosions have occurred because expansion of the hot water was cut off. This situation may result

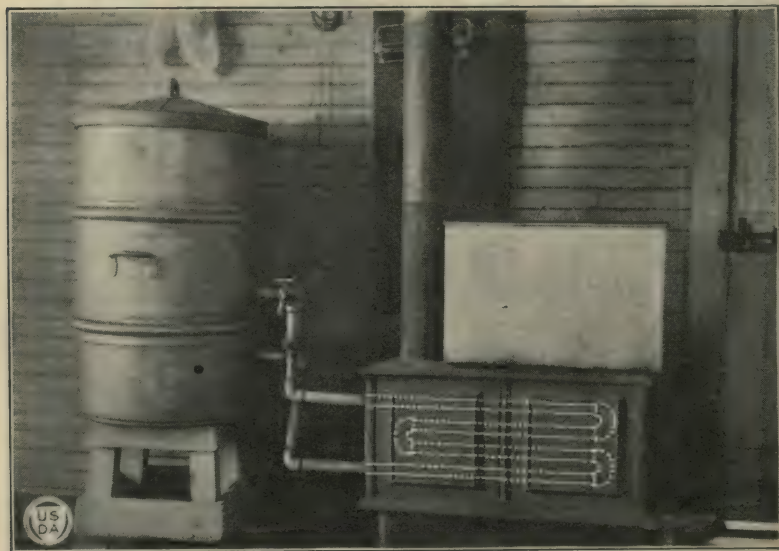


FIG. 34.—Homemade hot-water installation consisting of four lines of 1-inch black wrought pipe about 24 inches long joined by return bends and placed in a wood-burning stove and connected to a galvanized steel gasoline barrel 19 inches in diameter and 34 inches high; the barrel is supplied with cold water by pouring from a pail at the top; hot water is drawn at the faucet

from: (1) Frozen or scale-bound pipes; (2) thoughtlessly closing a valve on the cold-water line supplying a boiler under direct pressure; (3) use of a check valve or a pressure regulator on a direct-pressure cold-water supply; (4) nonoperation of a safety or a relief valve because of rusting and sticking.

The remedies are: (1) Lay the cold-water supply pipe below frost or otherwise protect it, and never allow the house temperature to fall much below freezing; if frozen pipes are suspected, open a faucet to see if the cold-water supply pipe is free; if not free do not start the range fire or gas heater until that pipe and all pipes from and to both the boiler and the source of heat have been thawed; the water back and connecting pipes should be cleared of lime deposit and rust whenever the circulation begins to get sluggish; the water back

should be removed and tapped with a hammer to loosen the lime or be filled with a solution of 1 part of muriatic acid and 7 parts of

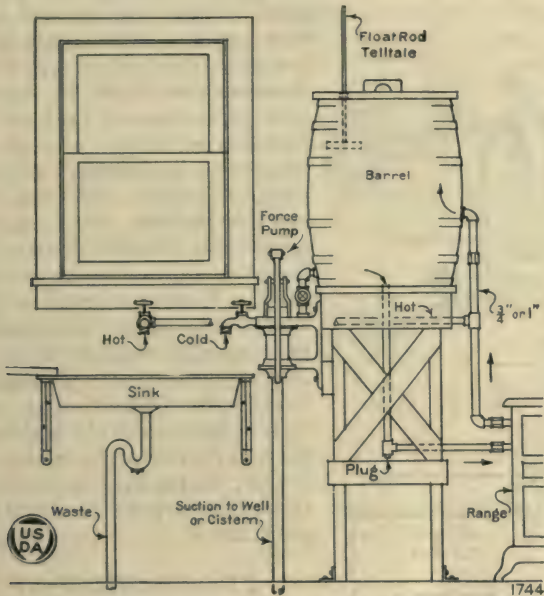


FIG. 35. —Homemade hot-water installation: as desired the pump forces cold water to the faucet or to the low side tapping in the barrel; hot water is drawn through the center side tapping and connecting pipe. By the use of a three-way valve or two single valves at the pump and suitable piping, the barrel or a tank could be placed above the kitchen, and thus supply cold water to a range boiler and hot and cold water to the sink faucets

water; after the line is dissolved, the water back and connections should be well flushed with boiling water to remove the acid; (2) for convenience in making repairs, a

valve is usually placed on the cold-water line between the range boiler and the source of supply; in a direct-pressure system this valve should never be closed when the gas heater or range fire is burning; (3) if a check valve is used on a metered service to prevent hot water backing up to the meter, the range boiler, if supplied by direct pressure, can be protected in two ways, (a) by attaching a safety or relief valve frequently examined to make sure that rust or sticking does not render it useless, (b) by placing a pipe or by-pass having a reversed check valve around the meter. A

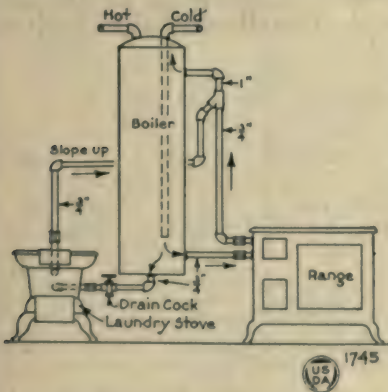
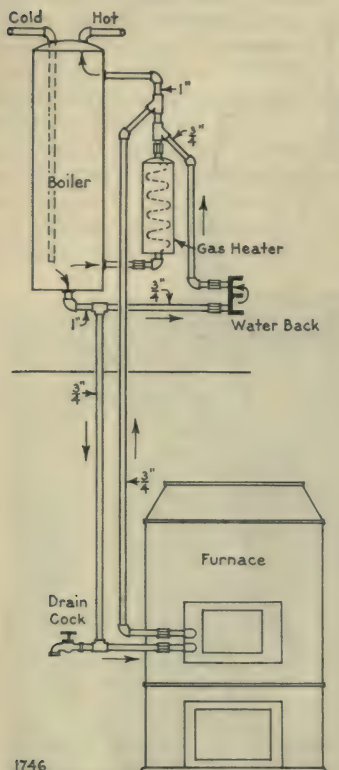


FIG. 36. —Boiler connected with a kitchen range and a laundry stove

relief valve should always be installed if the system has a pressure regulator or pressure reducing valve.

Chattering in faucets and pipes and rumbling or knocking in range boilers are annoying; they show faulty but not necessarily dangerous conditions as many suppose. These troubles are generally due to vibration, slow, scale-bound, or air-bound circulation, or overheating. Faucets should be in thorough repair and pipes should be well secured and have clean bores. Circulation is often improved by using larger or better pitched pipes. One hot-water faucet should branch off from the highest point of a closed circuit, thus allowing air to escape every time that faucet is used. With a very hot fire, a range boiler may pound or knock and steam may sputter forth when a hot-water faucet is opened. Pounding may be due to the formation of steam in the water back and its sudden condensation as it enters the cooler water in the boiler; steam at a faucet indicates that the boiler supply is above boiling temperature.



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FIG. 37.—Boiler connected with a kitchen range, a gas heater, and a furnace

PROTECTION OF PIPES

All pipes should be safe from frost. Small water pipes freeze quicker than waste pipes and sewers which carry water more or less warmed. Latitude and local soil and cover conditions vary the depth to which frost goes into the ground. A fair guide for the laying depth of small water pipes is given in Table 6.

TABLE 6.—Laying depth of small water pipes

State	Depth	State	Depth	State	Depth
	<i>Feet</i>		<i>Feet</i>		<i>Feet</i>
Alabama.....	1½ to 2	Kentucky.....	2 to 3½	New Mexico.....	2 to 3
Arkansas.....	1½ to 3	Louisiana.....	1½ to 2	New York.....	4 to 6
California.....	2 to 4	Maine.....	4½ to 6	North Carolina.....	2 to 3
Colorado.....	3 to 5	Massachusetts.....	4 to 6	North Dakota.....	5 to 9
Connecticut.....	4 to 5	Michigan.....	4 to 7	Ohio.....	3½ to 5½
Florida.....	1 to 2	Minnesota.....	5 to 9	Pennsylvania.....	3½ to 5½
Georgia.....	1½ to 2	Mississippi.....	1½ to 2½	Tennessee.....	2 to 3
Idaho.....	4 to 6	Missouri.....	3 to 5	Texas.....	1½ to 3
Illinois.....	3½ to 6	Montana.....	5 to 7	Virginia.....	2 to 3½
Indiana.....	3½ to 5½	Nebraska.....	4 to 5½	Wisconsin.....	5 to 7
Iowa.....	5 to 6	New Hampshire.....	4 to 6	Wyoming.....	5 to 6
Kansas.....	2½ to 4½	New Jersey.....	3½ to 4½	District of Columbia.....	4

At spots liable to be caught by frost pipes may be boxed and surrounded with dry shavings, excelsior, sawdust, leaves, chopped

straw, charcoal, granulated cork, pea or nut size coke, or mineral wool.

Within buildings it is more convenient to use a commercial covering of wool felt or hair felt lined with tar paper. These coverings come in sizes to fit different pipes and fittings. They are in 3-foot lengths, split on one or both sides to slip over the pipe, and are fastened with wires or brass bands. Figure 38 shows two widely used kinds. The wool felt covering for $\frac{3}{4}$ -inch pipe costs about 12 cents per foot. These coverings are sometimes used to deaden sound and to do away with condensation of moisture and drip from exposed overhead pipes. A good homemade covering is a tar-paper lining with a wrapping of felt, and the whole jacketed with canvas pasted or wired on and finished with a good waterproof paint. Old automobile tires cut in long narrow strips and wound spirally around the pipe are useful.

The insulation of hot-water pipes and range boilers may be asbestos cement applied in plastic form or a commercial covering of

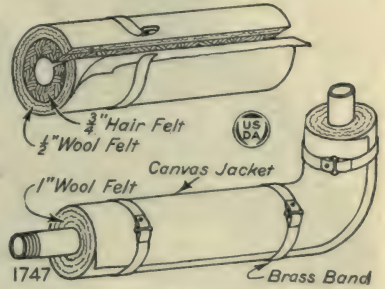


FIG. 38.—Two pipe coverings for protecting indoor water pipes from frost

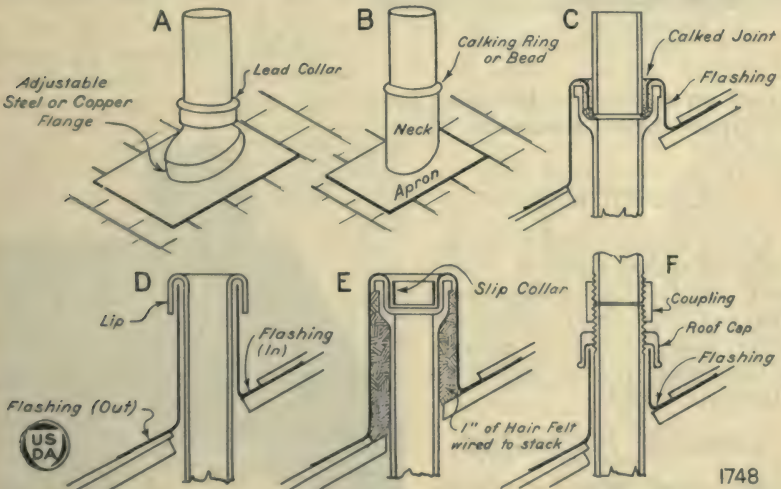


FIG. 39.—Six weather-tight roof connections. A, B, and D are simple commercial products adapted to pitched or flat roofs; B is a one-piece all-lead flange and D is a cast-iron pipe with extended lip covering the top of the flashing; C is ordinary cast-iron soil pipe with the flashing bent over and calked into the hub; E shows a good method of protecting a stack to prevent closure by frost; F shows a substantial screw-pipe roof connection

asbestos, magnesia, or plaster of Paris. Cork, hair felt, or wool felt lined with asbestos paper are very effective.

ROOF CONNECTIONS

Every pipe passing through a roof should have a lead, copper, or galvanized roofing flange. The apron of the flange is flashed into the roofing and the neck of the flange is made water-tight to the pipe 6 to 12 inches above the roof slope. The pipe is usually extended 12 to 18 inches above the roof, the shorter distance being preferable in very cold climates where the bore may be closed by frost. This trouble can be overcome by surrounding the pipe with 1 inch of hair felt or wool felt to completely fill the space between the neck of the flange and the pipe. Figure 39 shows six roof connections. Lead flanges are about 15 inches square and weigh 4 pounds per square foot (about $\frac{1}{16}$ inch thick). Copper and galvanized flashings weigh about 1 pound per square foot and approximate $\frac{1}{50}$ inch in thickness. Figures 40 and 41 show how the lead collar is



FIG. 40.—Dropping the lead collar upon an adjustable roof flange

placed on the adjustable roof flange and beaten or calked against the pipe to make a water-tight joint.

FLOOR DRAINS

Floor drains should not be installed unless there is actual need and frequent use, as in a creamery, cannery, slaughterhouse, pump room, or garage. A deep-seal trap as shown in Figure 42 is best.

CARE OF PLUMBING

Good, well-cared-for plumbing causes little trouble or expense. Frozen water pipes are a prolific source of trouble. Garbage, rags, newspapers, matches, and all other solids not readily soluble in water should never be thrown into water-closets or other fixtures; grease and fats should not be wasted through sink outlets. Solid substances clog traps and pipes;

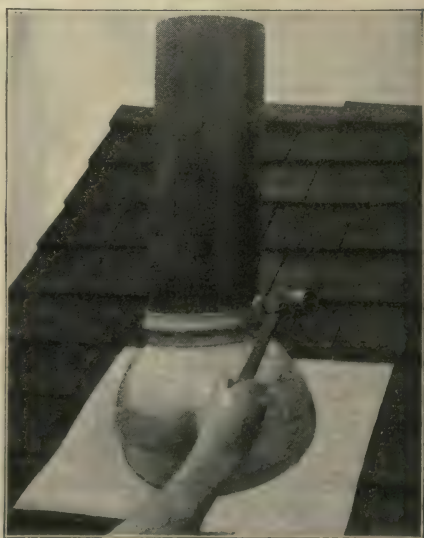


FIG. 41.—Beating down the lead collar to make a water-tight joint

greases adhere to the bore and gradually close it. Even the wash-stand trap may gather soap, grease, hair, and lint sufficient to stop it completely. After using a plumbing fixture, especially a kitchen sink, it is well to flush the trap and waste with clean hot water. Figure 43 shows simple tools for loosening and drawing out obstructions other than solidified grease. If a trap and the pipe leading from it have become solidly packed with grease, the trap should be disconnected at the slip and union joints and the grease should be dug out or be forced out with a stick. If a trap is not fully closed, the greasy matter may be burned out with a strong caustic solvent, of which numerous brands are on the market. The best costs respectively 50 cents in 1-pound and 80 cents in 2-pound cans, and the maker's directions for safely using are printed on the container. Caustic potash (lye) and caustic soda are widely used. Caustic soda is less effective than caustic potash because it unites with grease to form hard soap whereas potash forms soft soap. Caustic soda costs less—about 12 cents per pound in 10-pound pails—and constitutes most of the ordinary commercial lyes.

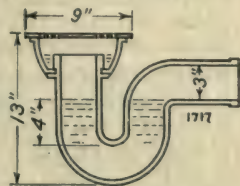


FIG. 42.—A typical floor drain and trap with 4-inch water seal

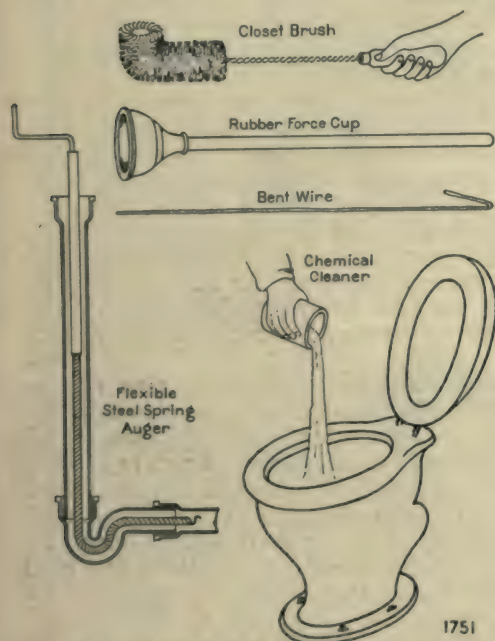


FIG. 43.—Simple appliances for the care of plumbing

Chemicals of the character described generate much heat, making them useful to thaw frozen pipes. Large quantities should not be used in or about plumbing because of the expense and the possible injury to pipes and fixtures. The chemical should be kept where children can not get it. The best use of drain-pipe solvents is as an occasional aid in keeping traps and pipes free and clean. Several times a year, or whenever the waste water begins to run away slowly, the pipe should be well flushed with boiling hot water to soften the grease. This should be followed with a strong solution of the chemical, and a half hour later the pipe should

be flushed thoroughly with clear boiling hot water. In this way little or no injury is done to the pipes and much of the grease will have been destroyed or washed away. If not successful at first, the process should be repeated. A quantity of the chemical should be dissolved in 2 quarts of cold water in a large pail, the solution being

well stirred and poured through a funnel directly into the pipe. The face, hands, clothing, or an open flame (in confined space) should not come in contact with the chemical or its fumes.

All fixtures should be cleaned daily. No sharp or pointed utensils, sandpaper, coarse, gritty powder, scouring soap, oil, acid, or acid preparation should be used because they tend to injure the thin shiny glaze, literally the skin of enameled and vitreous wares. The treatment should be much the same as with table crockery, relying mainly on soap and hot water. As needed a very fine specially prepared cleaning powder costing 25 cents for 1-pound cans may be used to remove grime and stains. A small quantity of the powder should be sifted on a damp cloth and the fixture be wiped out or lightly scoured, and rinsed with clean, warm water. A little kerosene on a cloth is sometimes used to remove paint and grease. Soap, water, and a brush are sufficient ordinarily for cleaning water-closets. If a vitreous bowl has become badly incrustated, discolored, and foul smelling, a small quantity of chemical closet cleaner may be sifted into the water in the trap, be allowed to stand several hours and then be flushed away. Figure 43 shows the method of applying the cleaner, which reaches and thoroughly cleans the inaccessible parts of the trap.

Faucets should never be jammed. If they drip after moderate pressure on the handle, it is because they need new washers. Washers are small round disks about $\frac{1}{8}$ inch thick; those of asbestos and rubber or fiber composition have largely replaced leather and are suitable for both hot and cold faucets. They cost little and are easy to put in after the water has been shut off. The operation is as follows: With a monkey wrench unscrew the cap nut over the stem packing at the top of the body of the faucet; take hold of the handle and turn it to the left to unscrew and to remove the stem from the body; with a small screw driver unscrew the washer screw at the bottom of the stem; replace the worn washer with a new one and replace the stem and cap nut. In making repairs of this kind it is a great convenience to have wheel handle valves installed on the fixture supply pipes just below the fixture as shown in Figure 22.

Small water pipes closed by rust or other obstruction are more or less successfully opened by pushing a steel wire through, flushing with a powerful pump, forcing muriatic acid through, or using a swab or wire brush attached to a small, flexible brass or steel rod. In long lines, the pipe may be opened at intervals and the cleaning be done section by section. If these remedies fail, the pipe should be taken up, cleaned, and relaid, or be replaced with new pipe.

Publications of interest in connection with this bulletin and mailed free on request by the United States Department of Agriculture are as follows:

- Farmers' Bulletin 904, Fire Prevention and Fighting on the Farm.
- Farmers' Bulletin 976, Cooling Milk and Cream on the Farm.
- Farmers' Bulletin 1099, Home Laundering.
- Farmers' Bulletin 1132, Planning the Farmstead.
- Farmers' Bulletin 1180, House Cleaning Made Easy.
- Farmers' Bulletin 1227, Sewage and Sewerage of Farm Homes.
- Farmers' Bulletin 1279, Plain Concrete for Farm Use.
- Yearbook Separate 824, Securing a Dry Cellar.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1427

POULTRY ACCOUNTS



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF BULLETIN 176

A DEFINITE RECORD of expenditures and receipts is one of the greatest needs of many poultry keepers.

This bulletin gives a simple system of keeping poultry accounts adapted either for a small flock or for a large poultry farm.

Combined with this system of accounting is a detailed statement of expenditures and receipts and an inventory of the necessary equipment for operating a 1,500-hen commercial poultry farm.

The records advised are simple, consisting of a monthly statement sheet, a yearly summary sheet, an inventory sheet, a balance sheet, and a daily egg record.

This bulletin is a revision of Bureau of Animal Industry Circular 176, a System of Poultry Accounting.

POULTRY ACCOUNTS

By ALFRED R. LEE, *Poultryman*, and SHEPPARD HAYNES, *Junior Poultryman*,
Animal Husbandry Division, Bureau of Animal Industry

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IMPORTANCE OF KEEPING RECORDS

ONE of the greatest needs of most poultry keepers is a definite record of expenditures and receipts. This is necessary to determine the extent of success or failure that is being made in the poultry work. A simple system is given in this bulletin by which the necessary records can be easily maintained. This same system may be used either by the poultry keeper who has only a small flock or by the commercial poultryman. A study of these records will enable the poultryman to determine which parts of the operation of the farm are profitable and where the costs are excessive. The actual equipment necessary and the amount of feed required for the operation of a commercial poultry farm are also given, thus combining the showing of poultry accounting with data covering the operation and equipment of an average commercial poultry plant of about 1,500 laying hens.

The blanks suggested for keeping the records are simple and practically self-explanatory. They are estimated on a basis of a 1,500 laying-hen plant, assuming that the owner, with the assistance of his family, can do the entire work on a plant of this kind except during the spring, when \$120 is allowed for extra labor. The owner's dwelling and the land are not included in these records, as these items are such variable factors. From 20 to 25 acres is a desirable size for a 1,500-hen poultry farm, although some successful farms of this capacity have only from 6 to 12 acres. It is estimated that the flock of 1,500 fowls will consist of 1,000 pullets and 500 yearling hens or breeders. To maintain this flock, 4,000 eggs would be required, out of which 2,500 chicks should be hatched, and allowing that 500 will die or be culled before market age. The remaining 2,000 should be raised, half (1,000) being cockerels, which will be sold as broilers, leaving 1,000 pullets to put in the laying pens each year.

NECESSARY BLANKS AND FORMS

The different blanks or forms necessary to keep the records are the following: Monthly summary sheet, yearly summary sheet, inventory sheet, statement sheet, and egg record. A sample sheet of each kind has been filled out for guidance, except in the case of the egg

record, which is given in blank. These forms or blanks can be ruled off on ordinary loose sheets of paper or in a blank book. The latter plan will usually be found more desirable, as it prevents the different sheets from becoming scattered. When separate sheets are used they should be, for convenience, not less than 8 by 10 inches. When a blank book is used one page can be used as the debit side of the sheet and the opposite page as the credit side, which will allow the use of a small-sized book.

The inventory sheet should be used at the beginning of each year. The sheet shown is filled in for a new farm, the buildings and equipment being estimated at the cost price. In succeeding inventories a deterioration of 5 per cent is allowed on buildings, 10 per cent on incubators and equipment, and 15 per cent on automobile, which depreciation is included in the statement sheet. The statement sheet shows the actual status of the operation of the farm for the year. An incubation record should also be kept, showing the number of eggs set, the candling tests on the seventh and fourteenth days, and the total number of chicks hatched.

A simple egg record for the year is also given in blank. It is desirable to keep a record of this kind in each house or pen, which is also quite helpful in improving the efficiency of the flock. The average production of the flock during the month is figured by adding the number of hens at the beginning of the month to the number at the end of the month and dividing this by 2, giving the approximate number of hens kept during the month. The average production will then be this number of hens divided into the total egg production for the period.

When only a small flock is kept, all eggs and chickens used at home should be credited to the flock at regular market value. This may also be done on a large poultry farm, although such items will only slightly affect the totals, and in many cases poultrymen merely figure that the poultry and eggs are a part of their living and do not consider it sufficiently important to keep a record of these products.

SAMPLE STATEMENTS

The following statements have been drawn up for White Leghorn fowls, in which the mortality of laying hens will be about 12 per cent for the year. Each hen will consume approximately 64 pounds of feed in one year; 19.5 pounds of feed are allowed to grow a Leghorn pullet to September 1, in addition to 6 pounds of feed allowed for the cockerels, to be marketed when they weigh $1\frac{1}{2}$ pounds. The selling price of the cockerels in June was 41 cents per pound and 31.2 cents per pound was received for those sold in July.

The prices paid for feed and those received for products will vary in each section and in different years. Those given here are for 1922. The price of the ration for the laying hens is figured at \$2.08 per 100 pounds, while the growing feed for the chicks, other than the small baby-chick feed, is figured at \$2.25 per 100 pounds. It is estimated that 100 eggs set will average to produce 62 good chickens. An average yearly production of about 131.5 eggs per hen is estimated, including both pullets and yearlings, one-third of the fowls being yearling hens. The average price of eggs, based on monthly sales, was 40.5 cents.

DR.

MONTHLY SUMMARY SHEET

Date (1922)	Item	Feed	Miscellaneous	Equipment	Total
March 1	2,285 pounds chick feed.....	\$80.00			\$80.00
1	500 pounds wheat.....	10.50			10.50
	500 pounds oats.....	9.00			9.00
	1,000 pounds corn.....	18.00			18.00
8	500 pounds bran.....	8.00			8.00
	500 pounds middlings.....	8.75			8.75
	500 pounds meat scrap.....	21.25			21.25
	1,000 pounds corn meal.....	18.00			18.00
10	2 tons coal.....		\$30.00		30.00
12	20 gallons gasoline.....		5.00		5.00
13	500 pounds wheat.....	10.50			10.50
	500 pounds oats.....	9.00			9.00
	1,000 pounds corn.....	18.00			18.00
22	200 pounds bran.....	3.20			3.20
	200 pounds middlings.....	3.50			3.50
	332 pounds meat scrap.....	13.85			13.85
	400 pounds corn meal.....	7.20			7.20
25	2,800 egg cartons.....		30.00		30.00
25	Express.....		15.00		15.00
25	Lumber.....			\$50.00	50.00
29	Labor.....		120.00		120.00
	Total.....	238.75	200.00	50.00	488.75

Date (1922)	Item	Market eggs	Hatching eggs	Market poultry	Breeding stock	Total
March 1	430 dozen eggs.....	\$137.60				\$137.60
8	430 dozen eggs.....	137.60				137.60
10	1,000 eggs.....		\$100.00			100.00
13	240 dozen eggs.....	76.80				76.80
22	430 dozen eggs.....	137.60				137.60
25	1,000 eggs.....		100.00			100.00
30	1,500 chicks.....				\$375.00	375.00
	Total.....	489.60	200.00		375.00	1,064.60

INVENTORY

Item	Inventory Jan. 1, 1922		Inventory Jan. 1, 1923	
	Number	Value	Number	Value
Buildings:				
Laying houses, each 20 by 120 feet (capacity, 1,500 hens).....	2	\$2,500.00	2	\$2,375.00
Colony brooder houses, each 10 by 15 feet (total capacity 2,500 chicks).....	8	800.00	8	760.00
Growing houses (also for cockerels), 10 by 15 feet.....	4	400.00	4	380.00
Garage and feed house, 20 by 40 feet.....	1	370.50	1	351.97
Fattening house and feed room, 18 by 36 feet.....	1	800.00	1	285.00
Total.....		4,370.50		4,151.97
Equipment:				
Mammoth incubator (3,000 egg capacity).....	1	500.00	1	450.00
Miscellaneous equipment—feed hoppers, wire fencing, water fountains, tools, wheelbarrow, pails, egg boxes, crates, etc.....		470.00		423.00
Large brooder stoves for growing houses, at \$30 each.....	8	240.00	8	216.00
Total.....		1,210.00		1,089.00
Auto truck.....	1	600.00	1	510.00
Stock:				
Pullets, about 9 months old, at \$3.....	985	2,955.00	985	2,955.00
Yearling hens for breeders, at \$2.....	485	970.00	485	970.00
Cockerels for breeders, at \$5.....	40	200.00	40	200.00
Total.....		4,125.00		4,125.00
Consumable supplies:				
Feed on hand..... tons.....	1½	60.00	1½	60.00
Grand total.....		10,365.50		9,935.97
Decrease.....		429.53		

YEARLY SUMMARY SHEET

DR.

Month	Feed			Miscellaneous	Equip- ment	Total
	Hens		Chicks			
	Pounds	Cost	Pounds	Cost		
1922						
January	7,791	\$162.05				\$382.05
February	7,711	160.39				465.39
March	7,632	158.75	12,235	\$30.00		488.75
April	7,420	154.34			Lumber \$50.00	384.34
May	7,287	151.57	5,000	112.50		330.07
June	7,115	147.99	5,800	130.50		318.49
July	6,890	143.31	5,000	112.50		330.21
August	3,975	82.68	5,925	133.31		375.99
September	7,500	156.00				306.00
October	7,600	158.08				208.08
November	7,950	165.36				250.36
December	7,870	163.70				223.70
Total	86,741	1,804.22	24,010	568.81	50.00	4,062.43
				1,629.40		

Baby-chick feed in March at \$3.50 per 100 pounds.

Poultry Accounts

Month	Market eggs		Hatching eggs		Market poultry	Breeding stock	Total cost
	Dozen	Value	Number	Value			
January	1,041	\$520.50				40 males at \$5.00	\$720.50
February	1,176	529.20					529.20
March	1,530	489.60	2,000	\$200.00		1,500 baby chicks at 25 cents	375.00
April	1,765	594.80	2,000	200.00		1,500 baby chicks at 21 cents	315.00
May	2,223	711.36					711.36
June	1,800	612.00			10 fowls at \$1.00		10.00
July	1,484	519.40			500 broilers at 61.5 cents		307.50
August	606	242.40			500 broilers at 46.8 cents		234.00
September	450	243.00			35 fowls at \$1.00		35.00
October	433	303.10			375 fowls at \$1.00		375.00
November	500	377.50				200 hens at \$2.00	400.00
December	668	427.52				200 hens at \$2.00	400.00
Total	13,676	5,540.38	4,000	400.00	961.50		1,690.00
							8,591.88

STATEMENT SHEET

Item	Dr.	Cr.	Balance
Value of inventory Jan. 1, 1922	\$10,365.50		
Interest at 6 per cent on capital invested not including dwelling or land	621.93		
Expenditures during 1922	4,052.43		
Value of inventory Jan. 1, 1923		\$9,935.97	
Receipts during 1923		8,591.88	
Total	15,039.86	18,527.85	\$3,487.99

YEARLY EGG RECORD

Day of month	January	February	March	April	May	June	July	August	September	October	November	December
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
Total												
Average number of hens												
Average egg production												

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1428

SAVING LIVESTOCK
FROM STARVATION
ON SOUTHWESTERN
RANGES



CATTLE AND SHEEP on Southwestern ranges are subject to severe losses from starvation during forage shortage caused by the ever-recurring droughts. To be prepared for these conditions by the establishment of range methods which anticipate them is essential.

Proper stocking, reserving part of the range for the critical period in every year, providing adequate water, close culling and other adjustments in the herd, supplemental feeding, and the giving of proper care and attention are practices which should be followed. These measures may cause a decrease in the herd and an increase in the cost per head, but the final results will be profitable because of fewer losses, a higher percentage of calves and lambs, increased quality and enhanced value of the animals, and better financial credit. The livestock industry will thus be placed on a more stable and a more profitable basis.

The practices herein recommended are based upon study and experience and should prove helpful to those engaged in livestock production in the Southwest.

Washington, D. C.

December, 1924

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SAVING LIVESTOCK FROM STARVATION ON SOUTHWESTERN RANGES

By C. L. FORSLING, *Director, Great Basin Experiment Station, Forest Service*

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Occurrence of drought and effect on carrying capacity	2	Early planning and attention necessary	21
Dangers of overstocking	3	Summary	22
Steps to prevent starvation loss among cattle	5		

EFFECT OF ERRATIC RAINFALL ON LIVESTOCK PRODUCTION

THE SOUTHWEST, including western Texas, New Mexico, Arizona, parts of southern California and southern Nevada, constitutes one of the important cattle and sheep producing sections of the United States. Because of the low rainfall the region is not well suited, without irrigation, to the raising of farm crops, but much of the land produces excellent native pasturage. The climate in general is so mild that livestock require no protection from winter weather, and it is the usual practice to graze them on the range throughout the year. The cost of production is therefore normally lower than in the sections where long winter feeding is necessary.

The region would be almost ideal for livestock raising were it not for the insufficiency of forage in times of drought. With livestock production principally on a yearlong range basis, when there is a shortage of range feed the number of animals lost is sometimes appalling. The so-called die-offs are often 25 to 50 per cent of all the cattle and include many sheep. Adverse climatic conditions have not infrequently necessitated the moving of thousands of livestock to regions where feed and water were available in order to avoid a total loss. As losses occur largely in the breeding herds and affect the producing end of the industry, several years are usually required for recovery from the setbacks.

REDUCTION IN CALF AND LAMB CROPS FOLLOWS FORAGE SHORTAGE

Because of open winters the Southwest is suited for the production of young stock; lack of proper forage, however, for bringing them to maturity necessitates their early disposal, and the livestock industry should be upon that basis. Maximum crops of calves and lambs

are of prime importance, and these crops are both heavily reduced by adverse conditions. As the death rate is greatest among cows heavy with calf and among ewes about to lamb, the loss of a cow or ewe usually means also the loss of a calf or a lamb. When range conditions are bad, poor cows or poor ewes are often not able to provide adequate nourishment for their young, and the mortality rate in offspring is unusually high after calving or lambing. Frequently cows with young calves are in such a poor condition in the spring and summer that they do not breed, and consequently calve only every other year. The low average annual calf crop in the Southwest is largely a result of this situation.

SERIOUS LOSSES RESULT FROM POOR CONDITION OF LIVESTOCK

Young animals are stunted by these unfavorable range conditions, and this further reduces the income from the livestock business. Calves or lambs that are undernourished the first few months of their lives do not make average weight at time of weaning or of sale. Cattle less than 4 years of age are commonly very much under the average weight of their respective age classes farther north, resulting in lower prices being paid and in heavy "cut backs" being made by purchasers.

The poor or emaciated condition of livestock frequently contributes to losses from other causes. Ordinarily the number of calves killed by coyotes on the range is small, but these losses increase when the mother cows are too weak to protect their young. The mortality from poisonous plants is invariably heaviest when livestock are hungry or when the range is closely grazed. Many poisonous species are among the earliest plants to make their appearance in the spring; and, if the supply of feed is short, livestock are attracted to them more than they otherwise would be.

Animals in a weakened condition are naturally less resistant to many diseases and to the infestation of such pests as lice and ear ticks. Outbreaks of scabies are usually more severe when stock are poor. Dipping or other treatment is an added expense, and losses result from the additional handling that becomes necessary. Many weak cows are lost in boggy places about springs and watering places and along streams where cattle drink.

Success and stability in the range-livestock business depend largely upon what can be done to minimize these losses. Any solution of the difficulties must deal primarily with the problem of providing more range forage, sufficient supplemental feed, and an adequate supply of water to meet the needs of the animals carried through the critical periods. As livestock in this region are dependent mainly upon range forage during the entire year, a more conservative range use is of first importance. Other measures, however, like the providing of supplemental feed and the better handling of the livestock will help to improve conditions (fig. 1).

OCCURRENCE OF DROUGHT AND EFFECT ON CARRYING CAPACITY

Droughts of 3 or 4 years duration may occur in the Southwest in each cycle of approximately 8 to 10 years. In addition, droughts of less severity frequently occur at irregular inter-

vals within these cycles. During these times the forage on the range may be materially reduced below that produced in average years. The amount of this variation will depend upon the locality and the duration of the drought. On the lower semidesert ranges the supply may be 50 per cent or less of the carrying capacity in average years. From that extreme it varies from 10 to 25 per cent reduction in the higher ranges, where the annual precipitation has less fluctuation. If, at the time of one of these droughts, the ranges are stocked on the basis of a full use of the forage available in an average year, the losses are liable to be extremely heavy.

Besides these frequent extended droughts, there may be a critical period in any year when the dry forage is low in nutritive value or when spring rains are scanty or lacking. This period extends from March until the summer rainy season, usually about the middle of July. Livestock are then in their poorest condition, and unless



FIG. 1.—Grade Hereford cattle on the range in the Southwest. More conservative stocking of the range, more liberal use of supplemental feeds, adequate water, and better care are essential to the welfare of the stock industry in the Southwest. Otherwise valuable breeding herds will sustain heavy losses or be entirely sacrificed in time of drought

measures are taken to meet this situation there are usually some losses.

Rodents, especially prairie dogs, do considerable damage and materially reduce the carrying capacity of many southwestern ranges. This effect is most serious in periods of drought when every blade of grass is needed by livestock. Systematic campaigns for their extermination have proven effective in their control.

DANGERS OF OVERSTOCKING

Any practice that results in the presence of more livestock on the range than the available forage crop will support is precarious. If there is dependence upon range throughout the year it is obvious that overstocking will result in a shortage of range feed toward the end of the grazing year, with consequent starvation. Stocking a range on the basis of the available forage will do much to minimize the heavy losses in the Southwest.

Even in years of normal rainfall overstocking may result from any one of a number of causes. Very often stockmen are apt to overestimate the carrying capacity because of a lack of knowledge of what the range will support or because of a failure to take into consideration all of the factors involved. Where land tenure is uncer-

tain, as on the unreserved public domain, and possession of the range is largely dependent upon such heavy use that other stockmen are discouraged from attempting to use it, overstocking is willful. If prices are high stockmen are sometimes inclined to overstock their ranges in an effort to increase production. On the other hand, if low prices prevail, stockmen may attempt to carry over salable animals for a higher market, with inevitable overloading of the ranges. Insufficient water on some areas has often caused overstocking of others.

The desert ranges of the Southwest are often overgrazed because of the lack of an adequate system of control. Many bands of sheep are dependent upon these areas for winter grazing. Since there are no means by which these ranges can be held intact through the summer months, they are often used by others during this period. As a result, there is little feed left when the sheep return in the fall, and unless winter rains and other favorable climatic conditions produce an abundant growth of annual plants, overgrazing and a shortage

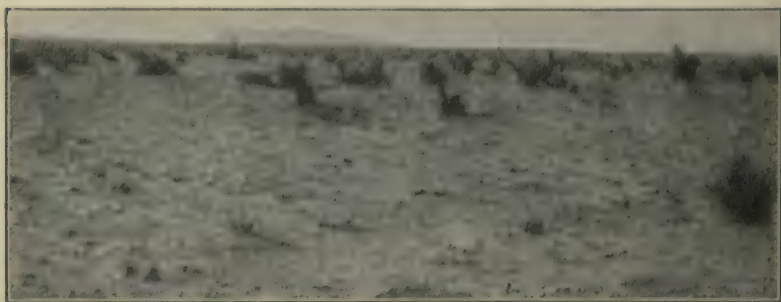


FIG. 2.—Range badly depleted by overgrazing and drought. Overgrazing must be avoided and adjustments must be made in the number of livestock to meet conditions of drought on the range.

of feed will surely follow. On many of the winter ranges conditions are not favorable for this production, and dependence must be placed on the closely grazed herbage produced the preceding summer.

The continued overstocking of the range invariably results in depletion of valuable forage plants and in a reduction of the carrying capacity (fig. 2). Although this decline is usually gradual, it often occurs at a rate faster than is realized by the users. To allow excess numbers to continue grazing after range deterioration has begun endangers the entire herd. Correct determination of the carrying capacity and stocking within the limits of that capacity are essential to the permanent welfare of the industry.

RANGE SHOULD BE STOCKED CONSERVATIVELY

The rate of stocking in average years should always be conservative, even to the extent of leaving unused 10 to 15 per cent of the palatable herbage of the important range plants. It is advisable to lose the use of that amount of forage each average year in order to have this margin available to meet unforeseen climatic conditions, and to avoid the risk of bringing about a gradual deterioration of the range.

The situation on the open range of the public domain can be remedied only by such a systematic regulation of its use as will permit more secure tenure, make lighter stocking possible, and provide for the reservation of areas for critical periods by fencing or other means.

Safeguarding against possible losses that might result from carrying over of salable livestock for a higher market, or from carrying through a few more head than the range will properly support, rests wholly with the owner. It is best to be on the safe side and dispose of surplus animals even on a low market.

STEPS TO PREVENT STARVATION LOSS AMONG CATTLE

The successful continuation of cattle production in the Southwest depends upon something being done to lessen the effects of drought. Years of experience and careful study have shown that the business may be so organized that many of the undesirable features will be eliminated. The available measures which should be followed are:



FIG. 3.—Good feed on a well-managed range. An ample supply of range forage throughout the year is the first requisite if livestock losses from starvation are to be avoided

(1) Limit breeding cattle to range capacity in poor years; (2) cull the breeding herd; (3) wean calves early; (4) reserve part of range for annual critical period; (5) develop adequate watering facilities; (6) provide feed to supplement grazing; (7) give proper care and attention to the cattle.

LIMIT BREEDING CATTLE TO RANGE CAPACITY IN POOR YEARS

The first step in reducing the loss from drought is to adjust the number of animals to the carrying capacity of the range during the critical periods (fig. 3). In other words, there should be a means of providing variation in the number of cattle on the range in accordance with the amount of forage produced in various years. As the Southwest is primarily a breeding section and as breeding cows are difficult to dispose of on short notice, this variation is not possible if the range is fully stocked with this class of animals. To meet the situation on the breeding range, therefore, the number of cows in the breeding herd should be restricted to what the range will carry in poor years.

This plan will provide sufficient range for the breeding herd at all times except during very severe drought, when supplemental feed is necessary, but will, of course, result in some surplus forage

in good years. This surplus feed may often be utilized profitably by holding over or buying young steers or occasionally heifers. Such stock can be moved readily, and if sold while in good condition they usually find a fair market. The age, number, and class of such cattle to be carried will depend upon the character and amount of range pasturage not needed for the breeding cows and upon the state of the market. The success of this plan, of course, is contingent upon disposing of the surplus animals as soon as a shortage in range forage for the breeding herd is imminent, and no attempt should be made to hold the surplus cattle for a better price or for improved range conditions. It is far better to sacrifice some of the surplus than to run the risk of heavy losses taking place among the breeding animals.

CULL THE BREEDING HERD

Old cows and weaklings should be culled from the herd and disposed of in the fall of each year. When a cow on the southwestern ranges reaches 10 years of age she has past her best breeding period and her ability to rustle for feed on the range has materially diminished. Usually by that time her teeth have become worn down or some of them have been lost. If she is left on the range, there is great danger of her dying or requiring extra feed and care, particularly in a dry year. Such cows are becoming much less salable all the time. It is therefore a desirable practice to dispose of these animals and replace them with vigorous young heifers. Some cows under 10 years appear to have weaker constitutions than the average animal and are less able to rustle for themselves on the range. Whenever such animals are detected they should be sold.

WEAN CALVES EARLY

It is the general practice in the Southwest to allow calves to follow their mothers until they are weaned naturally or sold. Obviously a cow will not do so well on the range when suckling a calf as when she has only herself to provide for. Ordinarily a calf will not make much growth during the winter and spring if its mother is not in good condition; in fact, the calf is benefited if it is weaned in the fall and placed on good grass range with a small ration of cottonseed cake or other concentrated feed. If the calves are weaned at 6 to 8 months of age, fewer of the cows will require additional care or feed than would otherwise be necessary in order to avoid loss. In a feed emergency these weanling calves should be marketed immediately.

If calves are weaned at 6 to 8 months (fig. 4) and placed on good pasture, they will require three-fourths to 1 pound of cottonseed cake per day to insure fair growth. Calves weaned under 6 months of age should be fed a small ration of alfalfa, silage, or some other available feed in addition to the range pasturage and the cake or meal to insure their growth. The early weaning and supplemental feeding of calves will result in less stunting and the yearlings will have a heavier weight. This gain is usually sufficient to offset the cost of feeding. Furthermore, the cows will be in better shape to breed and will raise a larger number of calves over a period of years.

RESERVE PART OF RANGE FOR ANNUAL CRITICAL PERIOD

The heaviest losses occur when the supply of feed on the ranges is getting short. Even though the range as a whole is not overstocked, poor cattle may still be underfed. On range used the entire year, the areas near watering places are naturally the first to be used following the summer rainy season. Then, when the critical period comes on and the cattle are in their poorest condition, they are forced to seek their feed at distances remote from water. This involves the loss of much energy and time that could otherwise be devoted to grazing. Range near water should be reserved for use during this critical period.

The ideal pasture arrangement would be to divide the range into two units, one for summer grazing and the other for winter range, with provision of smaller pastures for the poorest animals. Such a system would not only provide good winter range for all of the herd but would also allow part of the range to recuperate during the



FIG. 4.—Poor cows with large calves on a southwestern range. If calves are weaned when they are 6 to 8 months of age, cows will do better on the range. Earlier weaning and supplemental feeding are necessary in dry periods

growing season each year. Where part of the range is suitable for summer grazing only, such a division is needed to secure the best use of the feed.

Another advantage of the division of the summer and winter range is the opportunity afforded the stockman in the middle of the grazing year to check up the amount of feed available until the next growing season. If the summer-fall range becomes exhausted too early, it is usually safe to assume that the winter-spring range is deficient, and adjustments may be made accordingly. It is far more difficult to estimate the quantity of forage remaining at midyear, if the stock use the same range throughout the year.

Much of the grazing land in the Southwest is admirably suited to this division into summer and winter ranges. The higher mountain areas are suitable mainly for summer use, because of the climatic conditions. On the lower mountain slopes are found nutritious grasses which cure on the stalk, and a large amount of palatable browse which provides forage during the winter and spring.

Two or three main classes of forage plants occur on much of the lower semidesert range. These include galleta-grass, tobosa-grass,

grama-grasses, mesquite-grass,¹ and various species of browse. The galleta-grass and tobosa-grass are best suited for summer grazing, as they become dry and less palatable after the growing season. The grama-grasses are equally valuable for both summer and winter use. The browse is best adapted to winter and spring grazing. The combination of large areas of the summer grasses and of grama-grasses and browse on the same range unit lends itself very well to the division of summer and winter ranges. Where the forage on a range unit is all grama-grass or similar grasses, division is, of course, equally practicable.

DEVELOP ADEQUATE WATERING FACILITIES

An adequate supply of good clean water (fig. 5) within easy reach of the range at all times is essential to the welfare of livestock. Cattle in poor condition are, of course, less able to travel long distances to water. Watering places should not be more than 5 miles apart on comparatively level range and 1½ to 3 miles on rolling or rough range. Shorter distances give better results, especially with poor



FIG. 5.—An adequately equipped watering trough at a well in the Southwest. Properly spaced and well-equipped watering places are a profitable investment. Poor cattle are not able to travel more than 2½ miles to water on level range and ½ to 1½ miles on rough or rolling country, without detriment to the stock and injury to the range.

cattle. Watering places should be so well equipped that there will be no crowding of the animals around them or waiting for an opportunity to drink. Otherwise, the weaker animals are liable to be injured or prevented from drinking for several hours each time they come in for water. Starving for water for short periods is much more injurious than starving for feed. Heavy losses have occurred even when livestock were in good condition, because pumping equipment has broken down or been neglected. A stored supply of water should be available to meet emergencies.

In many localities tanks or reservoirs to catch run-off from rainfall (fig. 6) are used for watering livestock. Such places should be carefully watched, and cattle moved to other waters when the supply becomes exhausted or gets so low that weakened animals may “bog down” in the soft mud.

¹ Galleta-grass (*Hilaria jamesii*) ; tobosa-grass (*H. mutica*) ; grama-grasses (*Bouteloua gracilis*, *B. eriopoda*, *B. hirsuta*, *B. curtipendula*, *B. rothrockii*) ; mesquite-grass (*Hilaria belangeri*).

Approaches to drinking troughs should be kept dry and in good condition. If a weak cow slips down after drinking, she may be unable to get to her feet again, and die on the spot unless some one is at hand to help her. Troughs should always be so covered or protected as to prevent animals from falling into them or trying to step across them.

PROVIDE FEED TO SUPPLEMENT GRAZING

Even the greatest care in maintaining a good supply of range forage and water, particularly on the poorer ranges of the Southwest, will not avert all losses from starvation. The range is none too good at best during the winter and dry spring, and a few of the less thrifty cows, usually those with suckling calves or those heavy with calf, are liable to die if left to shift for themselves on the range. Moreover, there may be times when, as a result of unforeseen circumstances, the reservation of range or the taking of certain other measures may be insufficient to keep stock from becoming poor. In



FIG. 6.—A tank for catching flood water. These tanks are an important means of furnishing water for stock in the Southwest

times of prolonged drought the supply of range forage may approach depletion or become exhausted. The use of supplemental feeds, so far as it is economical, will assist in carrying the stock over these crises. The principal feeds available for this purpose in the Southwest are cottonseed products, irrigated and dry-land forage crops, and several native plants that may be prepared for stock feed.

Availability and cost of supplemental feeds, particularly cottonseed products and farm crops, have been determining factors in their use. Much depends upon the foresight of the stockman himself. When the critical period has arrived it may be difficult to obtain feed, or too late to get it to the cattle in time, or the cost may be excessive. The supply of crops is limited and may not be available in the quantity needed on short notice. Not uncommonly the fall price of cottonseed cake has doubled or trebled by spring when the demand is greatest. Cattlemen will usually profit by storing feeds early in the season or during good years when prices are always lower, as near as possible to the range where the cattle can be

fed conveniently. The interest on money thus tied up will, over a period of years, be far exceeded by the saving in the cost and in the added security and ability to meet emergencies promptly.

COTTONSEED PRODUCTS

Cottonseed products, particularly cottonseed cake or meal (fig. 7), when fed in small quantities as a supplement to range grazing will keep cattle from reaching a dangerous condition. The range forage is dry and usually low in nutritive value during winter, and the addition of the concentrate will make a better balanced ration. While cattle will subsist on this rich food alone for a considerable period, the best results can be had only when it is used as a supplement. It is well adapted for supplemental feeding on the range, especially if feed must be hauled a long distance. A supply sufficient for a large number of animals can be moved more cheaply than hay or other more bulky materials, and its distribution among cattle is a comparatively simple matter.



FIG. 7.—Feeding cattle cottonseed cake in troughs. A daily ration of three-fourths of a pound of cottonseed cake, together with dry range forage, forms an economical basis for maintaining breeding cows during critical periods. A larger number of calves and better growth will result

It is usually advisable to feed the cake or meal that has a protein content of 40 per cent or more, especially if the freight rate or the cost of haul from the railroad is high. Feed lower in protein serves very well, however, if the haul is short, but the amount fed should be increased to compensate for the deficiency in protein.

Unmilled cottonseed has also been fed with good results. The seed is a little cheaper than the cake or meal, but there is usually such a demand for the oil from the seed that the supply of unmilled seed for feeding purposes is limited. Cottonseed hulls are a valuable roughage, but their use is limited largely to the vicinity of the mills.

Quantity to feed.—The quantity to be fed will depend upon the condition of the animals, but usually three-fourths to a pound of cake or meal a day for each animal, with plenty of dry range forage, will make a maintenance ration. Thus a hundred pounds of cake per head for the average number of stock to be fed is adequate for a hundred-day feeding period, and this amount is ordinarily sufficient to provide for the usual critical period of the spring in the Southwest.

Placing the feed in troughs is generally the most satisfactory method of feeding; but cottonseed cake is eaten very well when it is

scattered on smooth, hard ground, the surface of which is free of sand, gravel, or small rocks. Cottonseed meal, however, can not be used with satisfaction on the ground. If high winds occur a considerable amount of the meal may be wasted, even when troughs are used. For this reason many stockmen prefer the crushed cake, which comes in small lumps.

Cost of feeding.—The cost of feeding cottonseed products varies with the market price of feed, distance from the mill, and length of haul from the railroad. Under normal conditions the higher grade of cake can usually be fed for \$40 to \$60 per ton. This amounts to \$2 to \$3 a head for the number of animals fed for a 100-day period on the basis of a pound a day for each head. When the smaller losses and larger calf crop are considered, that is a nominal cost per head.

IRRIGATED FORAGE CROPS

The use of irrigated forage crops as emergency feed for range cattle is limited largely to those animals located within a short distance of the irrigated areas. The practicability of using these feeds for this purpose depends very largely upon the cost of feeding and upon their availability at the critical period. Ordinarily there is such a demand in the Southwest for products of this kind for other purposes that it is uneconomical to buy them for range cattle except to a limited extent and for short periods of emergency or for high-grade animals. Alfalfa hay and silage provide the principal harvested forage; alfalfa and other stubble fields and winter-wheat fields supply much pasturage.

With other roughage available, 5 pounds of alfalfa a day, with a half pound of cottonseed cake, will keep a mature cow alive under emergency conditions. However, this ration is not sufficient for a pregnant cow if the calf is to be saved. Fifteen pounds daily of alfalfa, supplemented by 1 pound of cottonseed cake, will keep a mature cow in very fair condition during emergency periods. If sufficient alfalfa is used no supplement is needed.

Plants of the sorghum group produce heavy yields in comparatively short periods under irrigation. Where the growing season is long they may be grown on a piece of land from which an earlier crop has already been harvested the same year. A grown cow will require 17 to 20 pounds of silage with 1 pound of cottonseed cake per day for a maintenance ration. The cottonseed cake or meal may be eliminated if a larger amount of silage is fed.

The stockman who owns some irrigated land in connection with his range is in the best position to feed irrigated crops, because he is able to raise some feed each year and store it for a future emergency. There is also the added advantage of having some stubble fields for pasturage to tide over a few head of poor cattle.

Climatic conditions in the Southwest are such that alfalfa continues to grow for a considerable period after the last cutting has been made. If grazing is not too heavy it does not injure the alfalfa, and considerable feed may often be obtained in this way during the winter. The period of use will vary with the locality and the severity of the winter. Alfalfa fields may usually be rented for such grazing at a reasonable cost, though in some parts the rental has been high during certain seasons.

The area of winter wheat planted on irrigation projects in the Southwest is not large, but where it has been planted the fields will furnish considerable grazing during the fall and winter months.

DRY-LAND FORAGE CROPS

In parts of the Southwest where the average annual rainfall is 15 inches or more and soil conditions favorable, dry-land forage crops may be raised with a fair degree of success. Such crops are more uncertain in the parts where the average annual rainfall is less than 15 inches. At that, however, in the wetter years there is often sufficient moisture to raise a fodder crop in the drier parts, especially on areas that are flooded by run-off from near-by hills. Even under the more favorable dry-farming conditions, crops can not be expected every year, as approximately three to five years out of every ten are too dry for crop production. However, if a crop is raised every good year and stored for use in times of emergency, sufficient feed will ordinarily be available to carry stock through critical periods. The crop failure in drought years would, of course, increase the cost of providing the feed. However, as this feed is raised for emergency purposes, its value should not be reckoned in terms of current market prices, but should be considered as insurance against losses.

Plants of the sorghum group, particularly the kafirs, are best adapted to dry-land farming in the Southwest. The State experiment stations have done a great deal of work with these crops and are in a position to furnish information about the ones best adapted to any particular locality, the methods of planting, and other related matters.

SILAGE

Fodder crops may be kept for future use if harvested and stored dry or placed in a silo. Storing in a silo probably offers the best possibilities, as it preserves the forage values better than dry storage. Pit or underground trench silos have been found to give better satisfaction on the range in the Southwest than silos built above the ground. The soil in most localities is suitable for construction of this character, underground construction is cheaper, and the cost of maintenance is usually very low as compared with that of a silo built above the ground, particularly if lumber or metal is used. Wooden silos will not long withstand the dry atmosphere or heavy winds characteristic of the region, and the metal silos also are subject to damage by wind.

The ditch or trench silo offers an economical method of storing silage. The feed is placed in a trench or ditch several feet wide and several feet deep, dug with a team and scraper. The silage is then covered with earth to a depth of $1\frac{1}{2}$ or 2 feet. When stored in this way silage will keep for several years without deterioration.

NATIVE PLANTS

There are a number of range plants in the Southwest which, because of their spiny growth, toughness, or inaccessibility, are not in their native state available for stock. Chief among these are soapweed (*Yucca elata* and other species), Spanish dagger (*Yucca*

macrocarpa), sotol (*Dasyllirion wheeleri* and *D. texanum*), sacahuista (*Nolina* spp.), beargrass, also called soapweed (*Yucca glauca*), prickly pear and cholla (*Opuntia* spp.). Wherever found these plants may be made into feed by various methods and used to advantage during periods of emergency. However, because of their slow growth and the cost of making them into feed, their use at other times is less practicable and too expensive.

Soapweed.—Soapweed grows somewhat abundantly on the lower ranges in western Texas, southern New Mexico, and southwestern Arizona. Its use as emergency feed for cattle (fig. 8) has been well developed in recent years, and it has been fed for periods of six months or longer with satisfactory results. It is low in nutritive value, however, and a small quantity of cottonseed cake or meal should be fed in connection with it.

Soapweed is sometimes chopped and fed immediately after cutting, and sometimes it is stored as silage. In both forms it has ap-



FIG. 8.—Feeding poor cattle ground-up soapweed in troughs; 20 to 25 pounds of chopped soapweed with 1 to 1½ pounds of cottonseed meal a day will maintain a grown cow and may bring about a slight gain in weight

proximately the same feed value. There is no advantage in converting it into silage except that it is possible to have the feed ready when needed without extensive labor operations at the time. The making of it into feed requires special machinery and entails considerable labor. If this work is done at the time of feeding, it is usually necessary to concentrate a large number of cattle at one place or to duplicate the machinery and labor organization. If the feed is prepared beforehand and stored in a silo, the work can be done at slack time with one set of equipment and often at a smaller cost. With several silos located at vantage points on the range, it is possible for a few men to feed a large number of animals at each place successfully as occasion demands. Furthermore, no risk is run of breaking down the equipment or of some other difficulty arising that might cause a shortage in feed.

For feeding,² the plant is cut with an ax on the range, hauled to the site of the feeding operations, and run through a machine that cuts or shreds the plant into small pieces, after which it is placed

² For a full discussion of the feeding of soapweed, see "Chopped Soapweed as Emergency Feed for Cattle on Southwestern Ranges," by C. L. Forsling, U. S. Dept. of Agri., Bul. 745, January, 1919.

in troughs in the feed lot. Because the heavy stalk of the plant is peculiarly tough, a special machine is necessary. Several types of machines have been perfected and are available on the market in the Southwest. It is best to remove the dead, dry material from the stems of the plants before grinding. This may be done by burning either on the range before cutting or after the plants have been hauled to the machine. Unless there is danger of the fire spreading, it is most practical to burn the dead material on the range. One man with a torch is able to burn all that four men can cut and haul in a day. Burning the waste after the plants have been brought in means hauling a lot of waste material and requires an extra handling. Furthermore, unless the plants are very well scattered, the heat from the burning becomes so intense that much valuable material is lost.

Twenty to twenty-five pounds of chopped soapweed with 1 to 1½ pounds of cottonseed meal per day will maintain a poor cow and may bring about a slight gain in weight. The cost of converting and feeding soapweed varies from \$2.25 to \$3.75 per ton, depending upon the cost of labor and the length of haul. With cottonseed meal at \$40 per ton, it will cost \$1.45 to \$1.80 per month to maintain a cow.

There is very little danger of loss of cattle from feeding soapweed even for long periods if it is properly done. Occasionally an animal may choke to death on a large piece that passed through the machine. There is possibility of loss from bloat if a hungry cow gets all she can eat at the first few feedings, but this danger may be averted by feeding a small ration for two or three days. Because of its slow growth and the consequent length of time required for replacement of a stand, as well as on account of its low forage value, the use of soapweed should be confined mostly to meeting emergencies.

Spanish dagger, beargrass, and sacahuista.—Spanish dagger may be prepared and fed in much the same way as soapweed. However, it is not so abundant and is somewhat more difficult to handle because of its great toughness. It is found in practically the same region as soapweed, and where it grows in sufficient abundance it may be used to advantage as an emergency feed.

Beargrass, or low soapweed, is found north of the range of the tall soapweed. Although the stem is short the green leaves are valuable for feed, and if found in sufficient abundance this plant may be prepared in much the same way as the larger species. In its natural state the harshness of the leaves prevents its being grazed extensively. However, running it through a machine tears the leaves apart so that they may be readily eaten.

Sacahuista, also called beargrass, is another plant that resembles the true beargrass of the Southwest in its growth characteristics. Its occurrence is more limited than that of the plants already mentioned, but where it is found it has value as an emergency feed. Its preparation, however, does not require so heavy a machine.

Sotol.—Sotol is another semidesert plant closely related to the soapweed and beargrass that grow in parts of the Southwest. It has a food value higher, perhaps, than that of the other species,

but it is very much slower of replacement when it has once been cut. It occupies rocky soils on rough sites and therefore is not so accessible as the other plants.

The low, thick, barrel-like trunks or stems of sotol furnish the feed, and the leaves are practically worthless. Unlike soapweed, it can be prepared by chopping it to pieces on the range with an ax. It has been used to a considerable extent in parts of Texas for fattening stock. Its use for feed is limited as compared with the other plants, because of its scarcity. Furthermore, many areas that once supported good stands now have very little left. Wherever the plant is still found it may be used for emergency feed, but its use should be limited strictly to that purpose in order that a supply of it may be available when it is most needed.

Prickly pear and cholla.—Prickly pear has been used in Texas and other parts of the Southwest for a great many years both as emer-



FIG. 9.—Congestion of poor cattle at a feeding place. It is the better practice to begin early the measures calculated to prevent starvation rather than to wait until a large percentage of the animals reach a critical condition. Otherwise the available feeding facilities may be overtaxed, more feed will be required, and it can not be used to its highest efficiency

gency feed and for fattening livestock. Cholla also has been used as an emergency feed. Both of these plants are very spiny in their natural state but may be prepared by burning off the spines with a torch or by running the plants through a cutting machine which renders the spines practically harmless. The simplest method is to burn the spines on the range, the stock being allowed to follow and eat the plant. Special torches have been developed and are procurable on the market. If there is a large supply of the plants, one man equipped with a burner can prepare the feed for 200 to 400 head of cattle in a day. The best results may be had with prickly pear and cholla if a small ration of cottonseed meal or cake is fed in conjunction with them.

There is also a spineless variety of prickly pear that may be readily propagated in parts of the Southwest. As the absence of spines renders the plant available for grazing at all times, protection should be given, except when the feed is needed, to any area on which it is desired to reserve a supply. This protection must be against rabbits and other rodents as well as against cattle.

GIVE PROPER CARE AND ATTENTION TO THE CATTLE

The success of the measures calculated to prevent or minimize losses depends to a great extent upon the manner in which the stock are handled and upon the timely undertaking of the necessary safeguards. Unwarranted rounding up, rough treatment, and constant moving or disturbing of the herd are detrimental to weak animals and should be avoided. Some handling, of course, is necessary in getting animals to the feed lot and in grouping them for feeding (fig. 9), but it should be done slowly and carefully.

Range cattle are more excitable when handled than are farm cattle and may be slow in learning to take feed. This has led some stockmen to the opinion that good results are not possible in feeding range stock. There may be an occasional cow that can not be made to eat at all; but, as a general thing, even the most timid



FIG. 10.—A cow that got "down" because of lack of early attention. Attempting to save animals so weak that they are unable to get to their feet is an expensive undertaking. A prudent stockman will handle his business so as to avoid such a situation if possible

animal will learn to eat and become accustomed to the close handling and presence of people around a feed lot.

Attention should be paid to the stock on the range at all times. Their condition should be noted, particularly at the approach of the critical period, to determine the need for special care or feeding. The poor cattle should be placed on better pasturage or on feed. This may be accomplished by working the herd at watering places, or a rider may go over the range gathering up the poor cows and moving them carefully toward a reserve pasture or feeding ground without extra rounding up.

Feeding weak cows along with the stronger animals should always be avoided, for the weaker animals are driven back and do not get their share of the feed. Separate lots or pastures should be maintained so that animals in different degrees of emaciation may be placed where they will receive feed and attention (fig. 10) in accordance with their condition. The cattle in each lot should be carefully watched. Animals that have improved should be moved to the next lot up the scale, and cows that are not holding up should be moved to the next lot down the scale. This will insure those of equal strength being in each lot at all times, and the greatest benefit will be derived from the feed.

On the Jornada Range Reserve in southern New Mexico in 1918, during a drought, no less than five feed lots were maintained in handling the cattle. In one lot were placed the poorest animals, and they were fed all the soapweed they would eat with $2\frac{1}{2}$ to 3 pounds of cottonseed meal per day. Another group consisted of cows receiving all the soapweed they would eat, with 2 pounds of cottonseed meal per day. A third group received 20 pounds of soapweed and 1 pound of cottonseed meal per day. A fourth was fed cottonseed cake along with the range grass. A fifth was made up of dry and young cows that were able to subsist on range forage alone. All the various groups were carefully watched, and there was shifting from one group to another as conditions warranted. As a result losses were kept down without undue use of feed.



FIG. 11.—Ewes and lambs on summer range. Sheep prosper on the luxuriant forage on the high mountains of the Southwest during the summer months

STEPS TO PREVENT STARVATION LOSS AMONG SHEEP

The sheep business in the Southwest is subject to practically the same vicissitudes as the cattle business, but probably to a somewhat less degree of severity. Sheep are under better control and may be more readily shifted to meet changing range conditions, the increase in numbers is more rapid, and the returns from the business are earlier. This places the sheepman in a position to sell part of his stock when drought becomes serious and to build up the flock after the critical period has been passed. He may also go to considerable expense in providing reserve ranges, in feeding, or in moving his sheep to other range (fig. 11) in order to meet the decrease in carrying capacity of the range in case of emergency. Most of the sheep losses have been due to the neglect of one or more of these safeguards.

As a rule, the sheep-growers' losses are heaviest about lambing time. A large percentage of the sheep are wintered on the semi-desert range, where forage varies widely even under average conditions. Most of the ewes are bred to lamb early in the spring, in order that the lambs may be ready for the early fall market. This is the period when range feed (fig. 12) is most uncertain; and, if there is a lack of early rain or warm weather to bring on the spring growth, losses may be heavy. Under such conditions many lambs are stillborn and some are too weak to survive, or because of inadequate

milk supply starve to death shortly after birth. Weak ewes will frequently refuse to own their lambs. On higher lambing grounds many lambs are killed during late snows or cold rains as a result of exposure and decrease in milk flow. Many of the lambs that survive may be stunted and fail to attain average weight by the time of sale. High mortality is not uncommon among the ewes, particularly the older animals. Although it may be short, this critical season is often so severe that practically an entire lamb crop may be wiped out and many of the breeding ewes may be lost.



FIG. 12.—Ewes with young lambs on closely grazed range. Lambing time is the critical period of the year in the range sheep business in the Southwest. Losses are liable to occur if the range is closely grazed and spring rains are late in bringing on fresh green herbage

RESERVE PART OF RANGE FOR LAMBING

Good forage is needed during the lambing period. Selecting suitable areas of range (fig. 13) and reserving them for use during lambing will go a long way in reducing losses during the critical spring period. When lambing takes place on range that has been grazed all winter there is only scant feed left. Ewes with young lambs are not able to cover much ground for feed, and losses are bound to result if the forage is short. The reserve pastures will insure much better grazing. Such areas should have a grazing capacity sufficient to carry the ewes and lambs over the dangerous months. These pastures should be located where early green feed may most confidently be expected and where protection against storms is afforded. Adequate watering facilities should be provided. If these areas are fenced to prevent their being grazed the rest of the year, and to provide against predatory animals, the labor cost of handling the sheep during lambing time will be greatly reduced. As lambing pastures are used at a season when grazing is most injurious to the forage plants, it is important that grazing be prohibited the rest of the year to insure the largest possible forage supply during lambing. On the higher range, lambing sheds should be available in case severe storms occur (fig. 14).

Many of the sheep in New Mexico and Arizona are wintered on the open range of the public domain, where reserving of areas for use in the critical period of the year is impracticable with the present lack of regulation. Stockmen will therefore profit by purchasing private or State land at a reasonable price, or by leasing an amount sufficient to provide for the lambing period.

PROVIDE SUPPLEMENTAL FEED WHEN NECESSARY

The use of reserved lambing pastures is often sufficient to prevent lambing losses and insure an average lamb crop. Close personal attention to every lambing ewe is, however, absolutely necessary to success. In average years it is advisable to provide some feed in addition to the reserved range forage. In years below the average, extensive feeding or removal of sheep to other range may be necessary.



FIG. 13.—Young lambs with their mothers on the lambing range. Plenty of range forage is necessary if a large proportion of the lambs is to be saved. This forage may be provided by reserving an area of range for use only at lambing time. Such an area should have abundant feed, plenty of water, and natural protection against storms

If ewes have been bred to lamb about the time the first green feed usually comes in on the range, losses are liable to be heavy in the event of the spring rains being delayed even for a few weeks. It is too late to move the sheep after the lambing has begun, and it may not be possible economically to obtain feed at once. If, therefore, several months in advance, the sheepman has stored on the lambing range a quantity of feed sufficient to meet reasonable requirements, he has insured himself in the event of an emergency. Furthermore, he has probably had the advantage of buying in a lower market. Even if the feed is not needed that season, it will keep over until another year without much deterioration. In the meantime the herd will be safeguarded against severe loss from starvation.

COTTONSEED PRODUCTS AND GRAIN

Cottonseed cake or meal or other similar concentrated feed is valuable under most conditions for supplementing range feed for

sheep. When some roughage is available on the range, one-fourth pound per head per day of the concentrated feed will maintain the ewes in condition to furnish a good supply of milk and will insure a high percentage of survival among lambs. Corn, oats, or other grain may be used as supplemental feed with equal success, but in the Southwest it is usually more convenient to obtain the cottonseed products.

IRRIGATED PASTURES AND FORAGE CROPS

When irrigated pastures and forage crops are available they are important supplements to range forage for sheep (fig. 15). The flocks may be conveniently moved to the feed, and the additional cost of feeding during lambing time, particularly if range feed is short, will be more than offset by the survival of a larger number of lambs. Many sheepmen are taking their bands to the irrigated valleys for lambing rather than accept the risk involved in leaving



FIG. 14.—Lambing pens with sheds in central New Mexico. As severe storms may occur during lambing, it is a wise plan to provide sheds for sheltering the ewes and lambs

them on the range. In addition to there being an increase in the number of lambs "marked up," the ewes may be bred so that early-maturing lambs will be produced. Dry-land forage crops also may be used advantageously as supplemental feed for sheep.

NATIVE PLANTS

Soapweed, sotol, and prickly pear have been fed to sheep successfully, and wherever available they may be used to carry the animals over critical periods. Practically the same methods may be used in preparing these feeds for sheep as for cattle. The best success will be had if a small amount of cottonseed products is fed in addition.

CULL OLD EWES AND KEEP DOWN LOSS

Ewes should not be kept in the range bands after they are 5 or 6 years of age. Animals that have reached that age are less able to rustle forage than are younger sheep. Furthermore, if such animals are held over, they may not be in condition to mother lambs or

survive a critical period. The condition of the teeth usually determines whether or not ewes will do well on range feed. "Gummers," or animals with few or irregular teeth, are of doubtful value on the range and should be disposed of. The best time for culling is the fall, when sheep are in the best condition.

EARLY PLANNING AND ATTENTION NECESSARY

Success in keeping down livestock losses and reducing the cost of feeding depends very largely upon early attention. The recurrence of drought in the Southwest is so well established that provisions to meet it should be recognized in the livestock industry. The old adage that "a stitch in time saves nine" was never more applicable than in handling livestock. Good results can not be expected if they are allowed to remain too long on failing range before protective measures are carried out. If action is delayed until the danger point is reached, extensive feeding will be necessary and the facilities for handling the stock may be overtaxed. It is usually



FIG. 15.—A band of ewes and lambs grazing on an irrigated field. Some sheepmen find it profitable to arrange for the lambing to take place in the irrigated valleys, where there is plenty of feed. In this way lambs may be produced for the early market.

less expensive to maintain an animal in fair condition at all times than to bring about recovery after a severe setback.

Proper stocking, reserving part of the range, making adjustments in the classes of livestock retained, and providing for emergency feed are safeguards that can not ordinarily be arranged for after the critical period has arrived. These preparations require foresight and planning far in advance of the drought, and the uncertainty about when the critical time may come makes it advisable for the livestock raiser to be prepared at all times. The practice of running large herds to which suitable care can not be given, especially in times of emergency, should give place to the plan of carrying slightly smaller herds of better quality, which can be adequately fed and cared for during emergency periods. The cost of these safeguards may cut into the profits of the business in the good years; but the losses will be decreased, proportionately more calves and lambs will be produced, the raising of higher grade animals will be encouraged, and better financial credit will result. In short, this foresight would mean more efficient production, with the ill effects of adverse cli-

matic conditions largely eliminated, and the livestock business placed on a more stable and a more profitable basis.

SUMMARY

Frequent droughts constitute the chief menace to the livestock industry in the Southwest. Careful management, with foresight and planning in good years, is essential to meet these emergencies and place the industry on a more stable basis.

Overstocking has been one of the main factors in losses from starvation. In average years the range should be so stocked that 10 to 15 per cent of the palatable herbage of the important range plants is left unused. This will safeguard the range and allow some leeway in years a little below the average.

The breeding herd of cattle should be limited to the number the range forage can support in the "lean" rather than in the "fat" years. Any excess forage in good years may be used by surplus livestock which can be disposed of readily in time of drought.

The loss during the critical spring period may be offset to a large extent by reserving some winter range for use by poor cattle during this period. The ideal arrangement would be a division of the range into summer and winter grazing areas.

Breeding cows will do better on the range if calves are weaned in the fall at 6 to 8 months of age instead of being allowed to follow the cows all winter.

Poor animals should not be required to travel long distances to water. Watering places for cattle should not be over 5 miles apart on comparatively level range or more than $1\frac{1}{2}$ to 3 miles apart on rough range.

Supplemental feeding will assist materially in keeping down the loss. Cottonseed products, irrigated-land and dry-land forage crops, and native range plants that may be specially prepared are the principal feeds available. Dry-land forage crops may be raised in good years on favorable areas in the Southwest, and these may be harvested and stored for use during critical times.

Careful handling of the cattle, as well as segregating the weak animals and feeding them according to their needs, will prove advantageous.

Sheep are more readily handled than cattle, returns from the business are quicker, and there is usually a better market for this class of livestock. The number of sheep, therefore, can be adjusted more readily to a change in range conditions in time of drought than is the case with cattle.

The heaviest losses among sheep usually occur at lambing time. The reservation of lambing pastures and the supplemental feeding of cottonseed products, grain, irrigated-land and dry-land forage crops, and native range plants will control these losses to a great extent.

Success in safeguarding against losses depends largely upon preparedness to meet the situation and the timely taking of necessary action. The increased cost of the protective measures advised will be more than offset by the larger returns from a business thus made more stable and profitable.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1429



EMMER
AND
SPELT



EMMER AND SPELT are kinds of wheat the kernels of which are not removed from the chaff in threshing. Emmer and spelt are commonly but wrongly called "speltz."

Emmer was introduced into this country from Russia about 40 or 50 years ago. The States leading in the production of emmer are South Dakota, North Dakota, Nebraska, Minnesota, and Colorado. About 166,000 acres of emmer and spelt (mostly emmer) were grown in 1919. Spring emmer is best adapted to eastern North Dakota and South Dakota, but even there it usually yields less than the best varieties of barley or oats. Winter emmer is not an important crop in any part of the United States.

The Vernal (White Spring) or common emmer is the most productive spring variety, although Khapli appears promising in some sections. Both of these varieties are very resistant to stem rust.

Black Winter emmer is not very winter hardy or very resistant to rust or drought.

Spring emmer yields best when sown early at the rate of 6 to 8 pecks per acre.

Spelt is grown only on limited acreages, mostly in the eastern half of the United States. It is not resistant to the different kinds of rust, but is more productive than barley and oats in Maryland and Virginia. Winter spelt should be sown at the rate of 8 to 12 pecks per acre at the time winter wheat is sown.

Emmer and spelt are used principally as feed for livestock and have a feeding value about equal to oats and somewhat less than barley and corn. They also are used for making breakfast foods. Emmer and spelt are not suitable for the manufacture of bread-making flours in this country.

EMMER AND SPELT

By JOHN H. MARTIN and CLYDE E. LEIGHTY, *Agronomists, Office of Cereal Investigations, Bureau of Plant Industry*

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WHAT ARE EMMER AND SPELT?

EMMER AND SPELT are kinds of wheat which are grown to a limited extent in the United States. They differ from other wheats in that most of the kernels are not removed from the chaff (glumes) in threshing. The heads of both are fragile and break up during the threshing operation, leaving most of the meshes (spikelets) whole with the kernels inclosed (figs. 1 and 2). Some of the kernels always thresh out, however, the proportion depending on the adjustment of the threshing machine and the moisture content of the grain and straw at the time of threshing.

Emmer and spelt differ considerably in the shape and compactness of the heads and in other characters (figs. 3 and 4). The kernels of emmer and spelt are somewhat similar, being red in color and semi-hard or hard in texture. The kernels are long, slender, and tapering and have a long pointed brush. The uses of the two crops are much the same, but they are adapted to growing under very different conditions.

The name "speltz" is commonly used for both emmer and spelt by farmers and seedsmen in this country. The names "Russian oats," "spelz," and "spilts" also have been used. As emmer and spelt are distinct crops the word "speltz" should be discarded, and they should be known by their proper names.

Another kind of wheat, called einkorn, the kernels of which remain inclosed in the chaff like emmer and spelt when threshed, is not grown by farmers in the United States and therefore is not discussed in this bulletin.¹

¹ For further information concerning these crops, see U. S. Department of Agriculture Bulletin No. 1197, *Experiments with Emmer, Spelt, and Einkorn*, by John H. Martin and Clyde E. Leighty, 60 p., 3 pl. 1924.

EMMER

Emmer usually has pithy stems and velvety leaves. The heads are very compact and are flattened on the sides. The pedicels (joints of the rachis or stem of the heads) are short, narrow, and pointed and usually remain attached to the lower end of the meshes when threshed (fig. 1). The meshes are flattened on the inner side and contain two (or sometimes three) kernels.



FIG. 1.—Emmer spikelets, showing short and pointed pedicel attached to base

HISTORY

Emmer apparently has been grown since prehistoric times. It still is grown in many parts of Europe and Asia, although it is becoming of less importance. It is often of considerable importance, however, where agricultural conditions are unfavorable, as in some parts of Russia. Emmer probably was introduced into this country about 40 or 50 years ago by German immigrants from southern Russia who settled in the Dakotas. Other lots of emmer have since been introduced and distributed by the United States Department of Agriculture.

DISTRIBUTION

The States leading in the production of emmer are South Dakota, North Dakota, Nebraska, Minnesota, and Colorado, in the order named. Approximately 166,000 acres of emmer and spelt combined were grown in the United States in 1919, or about one-third of the acreage which was grown 10 years previously. The section producing the largest quantity of emmer lies in the eastern Dakotas. The distribution of emmer in the United States in 1919 is shown on the map (fig. 5).



FIG. 2.—Spelt spikelets, mostly without pedicel attached to base, but usually with the pedicel of the next spikelet attached to face



FIG. 3.—Vernal emmer (A); Black Winter emmer (B). Spike, side view, natural size; glumes from lower, central, and upper portions of spike, natural size; spikelet and kernel, magnified 3 diameters

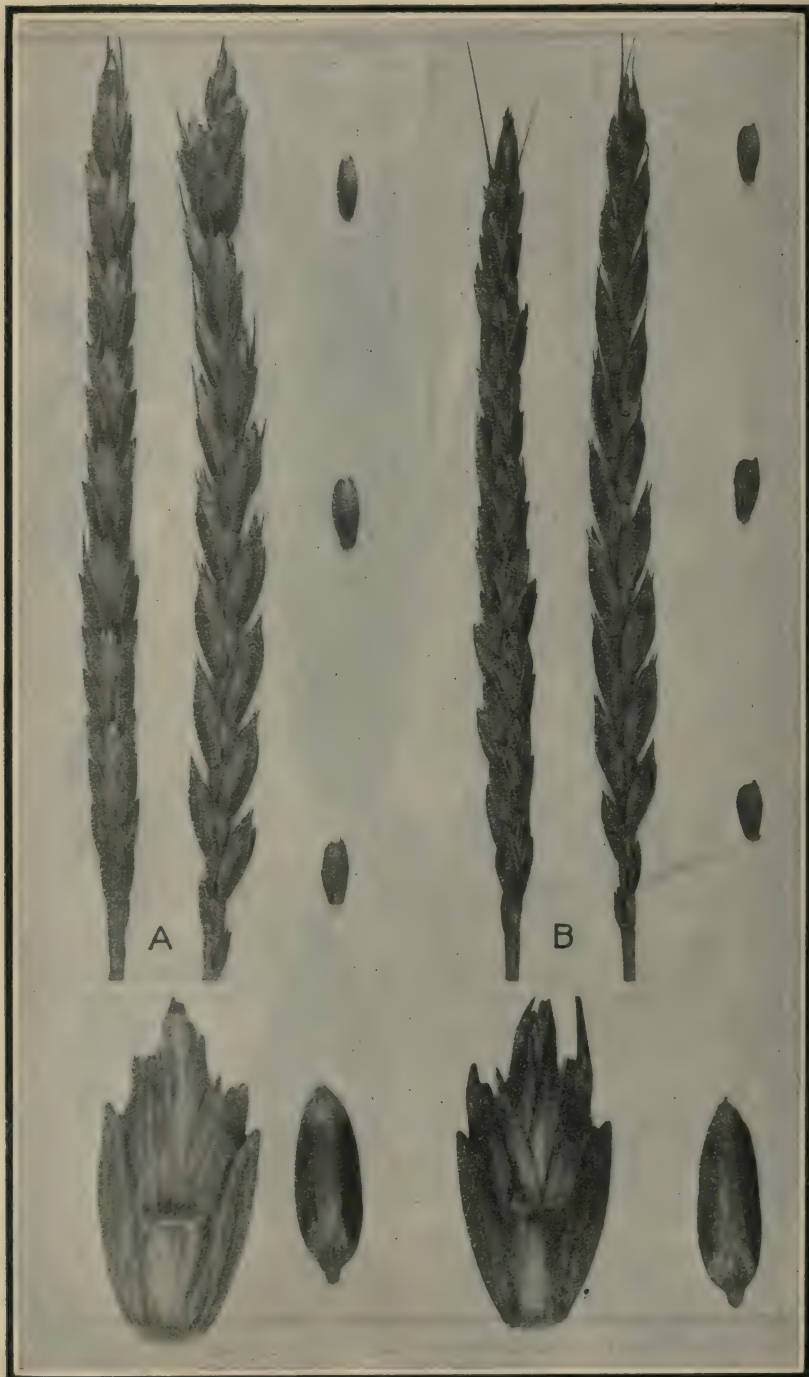


FIG. 4.—White Spring spelt (A) ; Red Winter spelt (B). Spikes, face and side views, natural size; glumes from lower, central, and upper portions of spike, natural size; spikelet and kernel, magnified 3 diameters

ADAPTATION

Emmer has been regarded as a drought-resistant crop with recommendations that it be grown in the semiarid regions. Experiments and experience in this country, however, have shown that it is not as productive as adapted varieties of wheat, oats, and barley under conditions of limited rainfall. Emmer is better suited to some subhumid sections than to the semiarid regions, and in the semiarid regions it gives better results in comparison with other small grains in moist seasons than it does in very dry seasons; in fact, it sometimes is a complete failure in dry seasons when certain varieties of other grains produce at least a partial crop.

Spring emmer is best adapted to the eastern portions of North Dakota and South Dakota and to western Minnesota. There it yields only slightly less than oats and barley, the feed grains with which it

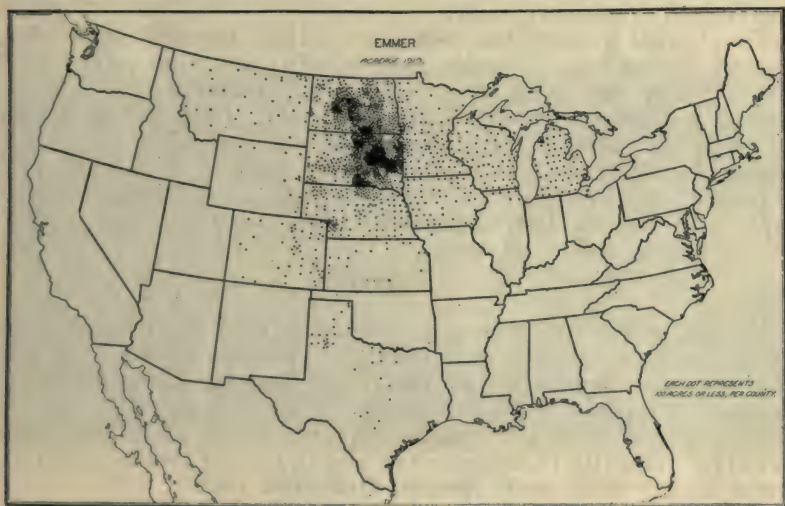


FIG. 5.—Outline map of the United States, showing the distribution of emmer in 1919, according to the United States census. Estimated area, 166,829 acres. Each dot represents 100 acres or less per county

competes, but in some seasons it outyields both of these crops. As spring emmer is very resistant to rust the growing of this crop offers a means of avoiding serious rust losses and may thus have a small place in the farming system because it permits greater diversification and thereby spreads the crop risks. In general, however, it is less profitable than other grains. Outside of the region just mentioned, spring emmer on the average can not compete with the better varieties of barley or oats, or both.

Winter emmer is not successful in the East or in the northern half of the United States because of its late maturity and lack of hardiness. In the Great Plains and Mississippi Valley areas it is not sufficiently hardy to survive the winter temperatures which occur in most seasons in the region north of Kansas. Winter emmer has given the best results in Utah and Arizona, and even there the yields of threshed grain without the hulls are less than the yields of winter wheat.

Winter emmer is thus not well suited for growing in any part of the United States, although some of it still is grown in Colorado and other States.

VARIETIES

A number of varieties of emmer have been introduced into this country, but only the three discussed here are now known to be grown commercially.

VERNAL (WHITE SPRING)

The Vernal (White Spring) or common emmer is the grain usually grown in this country as "speltz." It was first brought to the United States by German-Russian immigrants and grown in the Dakotas. In 1898, samples of this variety were introduced into the United States by the Department of Agriculture under the names Ufa and Yaroslav. Vernal is the only variety of emmer of any importance in this country now.

The Vernal variety has slender, nodding, bearded heads about 2 to 2½ inches long, glabrous (not velvety) white or yellow chaff, and purplish stems (fig. 3, A). It is very resistant to rust and is seldom injured by smut. It is grown only from spring sowing. In numerous experiments comparing Vernal with other varieties of emmer in the Great Plains and prairie regions, it has given the highest average yields, with few exceptions. With the possible exception of Khapli, Vernal probably should be the only variety of emmer grown in this country.

KHAPLI

Khapli, or Kathiawar, emmer was introduced from India by the Department of Agriculture in 1908 and was distributed in 1917 from the Highmore substitution of the South Dakota Agricultural Experiment Station. A small acreage of this variety may perhaps still be grown in South Dakota. Khapli differs from the Vernal variety principally in being earlier and in having shorter stems and wider heads. It is nearly immune from stem rust.

Khapli has given somewhat higher yields than Vernal in South Dakota and Colorado and therefore is of some promise in those States, although it frequently is rather short and somewhat difficult to harvest.

BLACK WINTER

Black Winter emmer was introduced from France by the Department of Agriculture in 1904 and was distributed to farmers later. Only a limited acreage, most of which is in Colorado, is now grown, because of the frequent losses from winterkilling. A field of Black Winter emmer growing in Texas is shown in Figure 6. A mass selection of this variety identical with the original strain was distributed in Wyoming about 1910 as "Buffum's Improved Black Winter emmer."

Black Winter has large bearded heads which are wide in one direction and narrow in the other. The chaff is bluish black or brownish black in color (fig. 3, B). Sometimes the heads are branched when grown under very favorable conditions. The plants are tall and are late in maturing. Black Winter emmer is not resistant to stem

rust or drought. It is not as hardy as most varieties of winter wheat, but is more hardy than winter varieties of barley and oats.

In all comparative experiments, reports of which are available, Black Winter emmer has yielded less than the leading variety of barley or oats and often is outyielded by both of these crops except at Nephi, Utah. The advantage of the leading variety of barley or oats, however, has not been large at McPherson, Kans., Channing, Tex., or Phoenix, Ariz. At Nephi, Utah, neither barley nor oats is well adapted, and winter wheat, the leading small-grain crop, produces higher yields of threshed grain without the hulls than does Black Winter emmer. This variety of emmer could generally be displaced by other crops with profit.



FIG. 6.—A field of Black Winter emmer growing at Channing, Tex.

CULTURE

SPRING EMMER

In the sections where spring emmer is adapted it should be sown as early in the spring as soil conditions permit. The best results have been obtained when it was sown with the grain drill at 6 to 8 pecks per acre, which is about the rate used for oats in the semiarid and subhumid sections. The drill should be adjusted the same as it is for sowing oats. Emmer requires the same soil preparation as other spring grains and occupies a similar position in crop rotations. The most profitable crops of emmer in comparative experiments have been obtained on corn ground, where the cost of production has been low.

WINTER EMMER

Winter emmer should be sown with the grain drill at the rate of 6 to 8 pecks per acre in semiarid sections. The best results are obtained if it is sown at the time most favorable for winter-wheat sowing. A depth of sowing of 1 to 3 inches is most satisfactory.

HARVESTING AND THRESHING

The heads of emmer are easily broken at maturity, and therefore the crop should be harvested before it is dead ripe, to avoid losses from shattering. Emmer is harvested and shocked in the same manner as wheat, oats, or barley. It is threshed easily, but care should be taken to avoid dehulling too many of the kernels. When threshed most of the kernels should remain inclosed in the chaff. The adjustment of the threshing machine is practically the same as for threshing oats.

SPELT

Spelt usually has rather large hollow stems and glabrous (not velvety) or slightly velvety leaves. The heads are long, slender, and open, with the meshes far apart and arched on the inner side. The pedicel (joint of rachis or stem of the head) is long and wide and after threshing usually remains attached to the face of the mesh below the one which it bears (fig. 2). Both bearded and beardless and winter and spring varieties of spelt are known. The winter varieties usually will produce seed from spring sowing in the spring-wheat area unless sown very late. Most varieties are rather tall.

Spelt can be distinguished from emmer easily by its long slender heads and by the longer, wider, and different attachment of the pedicels and by its larger hollow stems. The kernels of spelt are more flattened than those of emmer. Except for their manner of breaking up in threshing, spelt and emmer do not have many characteristics in common.

HISTORY

Spelt has been grown in Europe for 200 years, and probably much longer. It has been introduced into the United States on numerous occasions, several introductions having been made during the nineties. It was grown experimentally in California as early as 1893. More recently samples of spelt were imported from Germany by the United States Department of Agriculture. After being grown experimentally for a few years seed from these introductions was distributed to a few farmers in the Eastern and Southern States.

DISTRIBUTION

Statistics on the distribution of spelt alone in this country are not available, but apparently only a few hundred acres are grown. The data on spelt and emmer are combined in census reports. In 1919 about 166,000 acres of these two crops were grown in the United States, most of which was emmer. Most of the spelt is grown in the eastern half of the United States, although it occasionally is found in other sections. The frequent application of the name "speltz" to both of these crops by farmers and seedsmen makes reports on them somewhat indefinite.

ADAPTATION

Winter spelt is adapted to sections where winter wheat safely survives the winters. It has yielded less than the most productive variety of barley or oats and sometimes less than the leading variety

of both barley and oats in all comparative experiments conducted in the United States and Canada, reports of which are available, except at College Park, Md., Rosslyn, Va., and Nephi, Utah. At these places it considerably outyields both winter and spring barley and oats in pounds of grain per acre. Generally, however, spelt has not produced as large net yields of grain (kernels only) as winter wheat in those sections where it has surpassed barley and oats.

In experiments with spelt conducted at the Arlington Experiment Farm of the Department of Agriculture in northern Virginia near Washington, D. C., it has been observed that spelt produces larger net yields of grain (kernels only) than wheat in years and under conditions where wheat is badly lodged. Spelt has stood up better than wheat, also better than oats and rye, in wet years and on rich land and on wet or heavy land. This has resulted in the production of a good crop of spelt, while the yield of other crops was reduced by lodging.

Farmers in central Virginia who are growing spelt also report that it is a surer crop than oats; that it can be sown later in the fall, after the corn is taken off; and that the yield is much larger than that of oats, especially on poor land.

The results of experiments in which the three crops were compared indicate that spelt could profitably displace much of the barley and oats now grown for feed in certain parts of Maryland and Virginia, and possibly in central Utah. The crop should be tried more widely in these sections with this object in view. Lack of knowledge of the spelt crop and unavailability of seed have resulted in few trials of it being made. Where they have been made it generally has not been able to win favor from oats and barley, with the growing and uses of which farmers are thoroughly familiar. A new crop of this kind also meets with marketing difficulties. Any excess production can not be moved to market profitably in small lots, and even in the market could not be sold unless a demand existed. It is advisable, therefore, that the growing of spelt be limited to home or local needs until a market for the surplus production is known to exist.

VARIETIES

Although many varieties of spelt are known in Europe and several have been grown experimentally in this country, only two are now known to be grown commercially on a small acreage in the United States. Both are winter varieties and are described here. Neither is resistant to stem or leaf rust or loose or covered smut. They apparently are as winter hardy as most varieties of winter wheat. The winterkilling of spelt has not been experienced over a period of more than 10 years in the vicinity of Washington, D. C., and the coldest winters during this time have not reduced the yields.

One variety of spring spelt, White Spring (fig. 4, A), was distributed formerly by a seed firm in New York, but apparently it is not now grown on farms in the United States.

ALSTROUM

This variety has long, slender, open, nodding beardless heads with glabrous (not velvety) white or yellow chaff (fig. 7). The stems

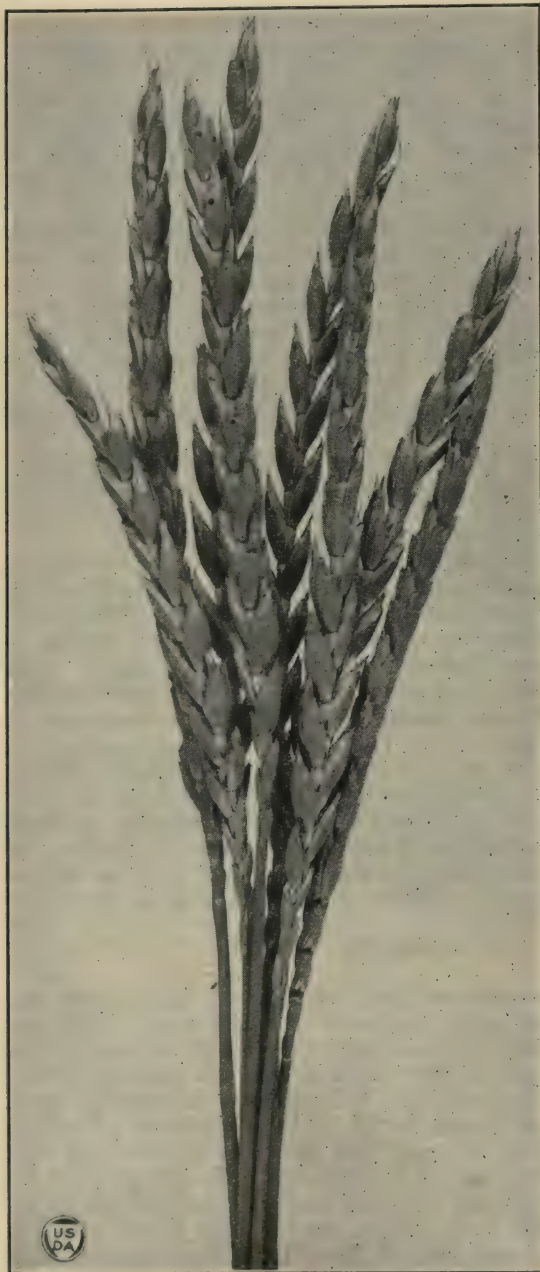


FIG. 7.—Heads of Alstrom spelt

height, time of maturity, and color of stems similar to Alstrom and, like the latter variety, can be matured from

are yellow, with sometimes a purple tinge. Although a winter variety Alstrom will mature seed rather late in northern localities even when sown in the spring. This variety was obtained by the Department of Agriculture in 1901 from the Washington Agricultural Experiment Station, by which station it had been introduced from Asia.

Considerable quantities of Alstrom spelt have been distributed to farmers during the past few years by the Department of Agriculture from the Arlington Experiment Farm, Rosslyn, Va. It is now grown to some extent in Maryland, Virginia, and North Carolina. Several farmers have reported good yields and general satisfaction with the crop. It should be given a thorough trial as a feed crop in these States.

RED WINTER

Red Winter or Red spelt differs from the Alstrom variety principally in having red or brown chaff and in having a few short-tip beards on the heads (fig. 4, B). In

Red Winter is very

spring sowing in northern localities. This variety appears to be more hardy than any variety of winter emmer.

Doubtless several lots of Red Winter spelt have been introduced from Europe. A sample was obtained by the Department of Agriculture in 1901 from the Washington Agricultural Experiment Station, by which station it had been introduced from Asia. Seed of this variety under the name Brown Winter also was introduced from Switzerland about 1913 by a farmer in South Dakota, who distributed it two years later. It was sown on a considerable acreage in the Black Hills district of South Dakota and Wyoming, but was almost entirely winterkilled during the rather severe winters which followed, and very little, if any, of this spelt is now grown. Red Winter spelt also has been distributed by the Department of Agriculture and several experiment stations, but it is not extensively grown.

This variety has yielded about as well as Alstroum in Maryland and Virginia. It is the most promising variety of spelt in the southern Great Plains and the Great Basin regions, where it usually out-yields Black Winter emmer. Because it has not compared favorably with winter wheat and some other crops, however, it has not become commercially important even in these regions.

CULTURE

The culture of spelt is very similar to that of wheat. The preparation of the soil, the rotations, and the fertilizers are the same for both crops. Spelt also should be sown at the best time for sowing wheat. It should be sown with the grain drill at the rate of 8 to 12 pecks per acre in the Eastern States, but less in semiarid regions. In order to sow at these rates it may be necessary to set the drill to sow a somewhat larger quantity, because the large grains pass through the drill rather slowly.

In drilling spelt and emmer on the Arlington Experiment Farm it has been the practice to set the drill feed as if sowing barley or oats. This has resulted in sowing about 70 to 90 pounds of seed per acre, which has given a fairly good stand but somewhat thinner than the usual stand of wheat. The presence in seed spelt of sticks, straws, and parts of spelt heads not fully broken up will interfere with proper feeding through the drill. Removal of such material by fanning and screening will result in more even seeding and a better stand.

Both spelt and emmer are slower in germinating than wheat, probably on account of the chaff which covers the kernels. In order to provide for the additional moisture which appears to be needed for germination, it has been the practice at the Arlington Experiment Farm when the seed bed is dry to seed both spelt and emmer somewhat deeper than wheat is sown.

HARVESTING AND THRESHING

The heads of spelt are brittle and break up in threshing with the kernels inclosed in the chaff (glumes) rather than shelled free, like wheat. In very dry regions or when the grain becomes dead ripe

before cutting, there may be some loss in the field from this breaking up of the head. The kernels are held very tightly, however, and if cutting takes place before the crop is dead ripe the losses from shattering in cutting and handling spelt apparently have not been as large as occur in wheat, oats, and barley.

Spelt is threshed with the ordinary threshing machine. Some attention should be given to adjusting the concave properly in threshing spelt. If the teeth are too close, too many kernels will be broken and shelled out from the chaff. If they are too far apart, many of the heads will not be completely broken up. Entire heads or heads only partially broken up make difficult the proper cleaning by the machine and later will interfere in sowing the grain with a drill. Attention must also be given in threshing to use the proper riddles in the machine for cleaning the threshed grain.

USES OF EMMER AND SPELT

As ordinarily threshed most of the kernels of emmer and spelt remain inclosed in the hulls, or chaff, which comprise about 20 to 30 per cent of the total weight of the grain. In chemical composition, emmer and spelt are somewhat similar to oats, and experiments indicate that these grains are about equal to or slightly better than oats and somewhat inferior to barley and corn in feeding value. The kernels of emmer and spelt with the hulls or chaff removed have about the same composition as wheat.

Nearly all of the emmer and spelt grown in the United States is fed to livestock. It should be ground before being fed. Because of its bulk, emmer and spelt give better results when mixed with other grains or concentrates, such as corn, barley, or linseed meal. The straws of emmer and spelt are about equal in feeding value to wheat straw, although stock will sometimes leave wheat straw for spelt straw.

In Europe emmer and spelt often are used in making food products. Sometimes they are dehulled and ground into a meal which is used for porridge. Some emmer is being milled into an uncooked breakfast food in this country. In Germany spelt sometimes is harvested before it is ripe, and the dried immature kernels, called grünkorn, are used in soups, porridge, etc.

Flour from emmer and spelt produces an undesirable dark, heavy bread, and when flour is made it is used mostly in mixtures with wheat flour. These crops are not suitable for the manufacture of bread-making flours in this country.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

April 9, 1924

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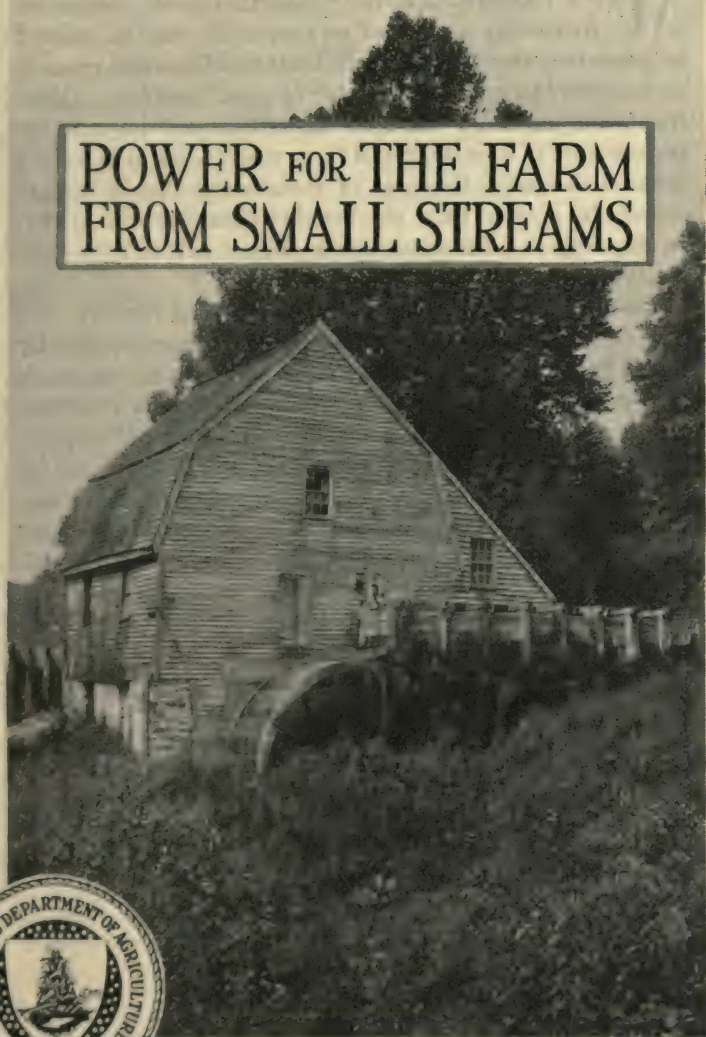
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1430

POWER FOR THE FARM FROM SMALL STREAMS



U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY
WASHINGTON, D. C.

MANY FARMERS do not realize that small streams are frequently sources of power which may be utilized in generating electricity to light their buildings and grounds and possibly to operate a number of small machines. Electrical equipment on the farm saves time and labor in the performance of household and farm work, but if it is to be a sound investment the cost of installation should not, of course, be greater than the benefits obtained will justify. In this respect farm water-power electric outfits have their limitations.

The purpose of this bulletin is to acquaint farmers with the possibilities of developing the power of small streams by converting it into electrical energy and the uses to which such power can be put; to give information which will enable them to avoid unnecessary expenditures; to explain how to determine the power a stream will supply; and to indicate the sources from which to secure additional information in regard to the approximate cost of installing a plant suited to the power available. The details of design, installation, and operation of electrical equipment are not within the scope of this bulletin.

Washington, D. C.

Issued January, 1925.

POWER FOR THE FARM FROM SMALL STREAMS

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SMALL STREAMS AS SOURCES OF ELECTRIC POWER

MANY STREAMS apparently too small to produce power for practical purposes may be so developed as to furnish enough power for the common needs of the farm; others may provide sufficient power to electrify an entire farm.

Electric power makes possible the use of many labor-saving devices and conveniences. Sometimes the power available will be sufficient for only a few lights. Often, however, plants may be installed large enough to supply from 2 to 5 horsepower during the entire year, and this will meet the requirements of the average farm. In exceptional cases it is possible to provide a plant capable of furnishing 50 to 100 lights and current for operating a washing machine, iron, vacuum cleaner, electric fan, toaster, percolator, sewing machine, a cooking range, etc., as well as such farm machinery as wood saws, corn shellers, and threshers.

Whether it will be profitable to develop a particular power site should be determined before any expense is incurred, and the question is one which the owner must decide for himself. He can determine the amount of available power by methods described in this bulletin and can form an estimate of the power required for each of various operations. From manufacturers of wheels, generators, batteries, etc., he can ascertain the cost of the equipment which must be purchased. He can form an approximate estimate of the cost of a dam, flume, and other construction work. Against this total cost—or the interest on the sum—he must weigh the advantages to be gained. Many of these, such as the greater convenience, can not be estimated in dollars and cents, but time and labor saved by doing many things with electric power can be valued approximately. If that time and labor can be utilized profitably in other ways their value may be credited to the cost of installation.

The first cost of a small water-power plant is usually greater than that of a similar plant driven by an engine, but the operating cost of the former is less, and its depreciation is slower. Sometimes an abandoned milldam can be repaired, and by the installation of the proper machinery electricity can be supplied to a group of farms at a reasonable cost. Such an undertaking may be developed as a cooperative enterprise, or the owner of the site may supply himself with current and sell the surplus to his neighbors. However, small streams do not usually offer opportunity for such development. If it is necessary to construct a dam of considerable size, the return usually will not justify the expense.

Electric plants run by water power can not be bought set-up and ready to work; each plant must be designed to fit the local conditions. Although the average owner can do most if not all of the construction work, the advice of some one familiar with water-power development should be secured. Information of this sort can be obtained from the State agricultural colleges, and the United States Department of Agriculture. Manufacturers of water-power apparatus also are glad to extend assistance to anyone seriously considering a project. They are usually prepared to supply a descriptive booklet containing general information on developing water power, accompanied by a questionnaire, so that the owner may submit data relating to the project and thus enable the manufacturer to recommend the most suitable machinery and advise as to its cost. This service is free of charge. If an order is placed, manufacturers will usually prepare a complete general arrangement drawing without extra charge, showing how the apparatus should be set and giving the dimensions of the required equipment. In some cases the purchaser is advised as to the successive steps to pursue when installing the machinery in order to secure the best results. The services of an expert erecting engineer will be furnished if desired for a stipulated amount per day plus living and traveling expenses, but for small installations the cost will usually prohibit the employment of such help, and generally it is not required.

The farmer who attempts to construct a plant without full knowledge of the requirements is apt to incur needless expense, and in some cases complete failure may result. As an illustration, a Maryland farmer purchased "a complete secondhand water power outfit" advertised in a farm paper with the idea of installing it on a small brook. The material was received in good condition and was exactly as advertised. As the purchaser did not know how to install it, he secured the assistance of an engineer familiar with small water-power development who returned the disappointing report that the greater part of the equipment was not suited to the particular stream and that the electric generator required a stream capable of supplying five times the power that could be obtained.

POWER

The power that can be obtained from falling water depends upon the volume of water which passes a given point in one minute and the height through which the water falls. The power afforded by the falling water is expressed in horsepower. The volume of water

passing is usually expressed in cubic feet per minute and the height of fall, or head (fig. 1), in feet. Table 1 will enable the farmer to determine the volume of water after he has made simple measurements of the velocity of the stream and its cross-sectional area by methods that will be later described and the height of fall can be measured directly. Knowing the volume of water and height of fall, from Table 2 he can find the horsepower that can be developed from the stream, disregarding power losses that occur when water power is



FIG. 1.—Head of water. The useful fall is that distance between the supply level and the surface of the tail-water

converted into electric power. In estimating the electric power at the points of application, it is best to divide the horsepower given in the table by two so as to allow for all conversion and transmission losses. The value thus obtained may be considered a conservative basis for rough calculation and will not necessarily indicate the exact amount of power that may be utilized. The efficiencies of the different units and the transmission losses will determine the relation between the water power and the actual electrical energy available for lighting and other farm uses.

TABLE 1.—Cubic feet of water per minute

Cross-section area (square feet)	Average velocity in feet per second (taken as eight-tenths surface velocity)									
	½ foot	1 foot	1½ feet	2 feet	2½ feet	3 feet	3½ feet	4 feet	4½ feet	5 feet
1	30	60	90	120	150	180	210	240	270	300
2	60	120	180	240	300	360	420	480	540	600
3	90	180	270	360	450	540	630	720	810	900
4	120	240	360	480	600	720	840	960	1,080	1,200
5	150	300	450	600	750	900	1,050	1,200	1,350	1,500
6	180	360	540	720	900	1,080	1,260	1,440	1,620	1,800
7	210	420	630	840	1,050	1,260	1,470	1,680	1,890	2,100
8	240	480	720	960	1,200	1,440	1,680	1,920	2,160	2,400
9	270	540	810	1,080	1,350	1,620	1,890	2,160	2,430	2,700
10	300	600	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000
12	360	720	1,080	1,440	1,800	2,160	2,520	2,880		
14	420	840	1,260	1,680	2,100	2,520	2,940			
16	480	960	1,440	1,920	2,400	2,880				
18	540	1,080	1,620	2,160	2,700					
20	600	1,200	1,800	2,400	3,000					
22	660	1,320	1,980	2,640						
24	720	1,440	2,160	2,880						
26	780	1,560	2,340							
28	840	1,680	2,520							
30	900	1,800	2,700							
35	1,050	2,100								
40	1,200	2,400								
45	1,350	2,700								
50	1,500	3,000								

Flow (cubic feet per minute)	Head in feet																			
	2	3	4	5	6	7	8	9	10	12	14	16	18	20	25	30	35	40	50	
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DETERMINING THE FEASIBILITY OF WATER-POWER DEVELOPMENT

A preliminary survey and estimate is essential in ascertaining whether the project is feasible. This should consist of (1) determination of the power available as explained above; (2) determination of the height and length of dam required, if any, and the probable effect of backwater upon adjoining farms; (3) comparison of the power available with the power required; (4) location and type of plant.

The measurement of the water and the head can be made with sufficient accuracy by the owner of the site, and usually he will be able to secure the other data. If the owner is not able to use a surveyor's level and is not sufficiently versed in the subject to make the best selection for the power and dam site and to decide upon equipment that will be the most suitable, it will be advisable to secure the assistance of an engineer familiar with such work before ordering material or beginning construction. The setting of a small wheel involves no great difficulty and can usually be done satisfactorily by the owner who follows carefully the instructions supplied by the manufacturer.

MEASURING THE STREAM FLOW

The particular object in measuring the flow of the stream is to determine the smallest amount of water that may be expected at any time during a period of years, as this is usually the controlling factor in designing a plant. The measurement of the flow of a stream should be reasonably accurate, but attempts to secure extreme accuracy are a waste of time, since the flow varies from day to day, season to season, and year to year. The measurement of a stream for a single day may be worth very little, and for this reason it is advisable where possible to make frequent measurements and record each with the date. If, however, only a few measurements can be taken, the flow to be expected at other times of the year may be approximately ascertained by questioning persons who have lived near the stream for a number of years and remember the extreme low and high water stages. The best time to obtain an idea of the power possibilities of a particular stream is during a low-water stage following an extended dry period.

In measuring the volume a fairly straight course of the stream should be selected, with a uniform cross section and free from cross currents, backwater, or eddies. The volume of water may be measured either by the cross-section-velocity method or by weir measurement.

CROSS-SECTION-VELOCITY METHOD

At the upper end of the course two poles should be placed on opposite sides of the stream as shown at A and B, Figure 2, so that a line stretched across between the poles will be at right angles to the direction of stream flow. At the lower end of the course two other poles, C and D, should be similarly placed. The length of the poles will depend on the height of the banks, but they should be long enough when driven into place to hold the lines in a horizontal position near the surface of the water. The distance between these lines should be governed by the velocity of the water; for a slow stream 50 feet will be sufficient, while for a swift stream the length of the course should be from 100 to 200 feet.

The distance between the upper and lower lines on each side of the stream should next be measured accurately with a tape; the average of these two measurements may then be taken as the approximate distance between the lines.

The rate at which the water is flowing is determined by means of a float. A lemon makes a good float, or a croquet ball may be used. The float should be placed in the water a sufficient distance above the upper line so that by the time it passes under the line AB (fig. 2) its velocity will be the same as that of the surface of the stream.

The time required for the float to pass from the upper to the lower line should be carefully noted. Several trials should be made with the same float, starting it at various distances from the shore. The average time in seconds required for the float to pass between the lines may then be determined and this time, divided by the distance in feet, gives the velocity of the surface of the stream in feet per second. The velocity of a stream is usually greatest just below the



FIG. 2.—Stream measurement, cross-section-velocity method. This method is used where the width of the stream is such that it is impracticable to set a weir (see fig. 4)

surface and least near the bottom and banks. The average velocity of the entire stream is approximately eight-tenths of the surface velocity as determined by float measurements.

Having determined the average velocity in this manner the cross-sectional area of the stream must be measured. This may be done by attaching tags to the lines at equal intervals (see fig. 3) and measuring the depth of water under each tag. The average depth in feet multiplied by the width in feet gives the approximate cross-sectional area in square feet. Cross-sectional measurements should be made at both stations and averaged.

The flow of the stream in cubic feet per minute can then be found by referring to Table 1. In the vertical column corresponding to the average velocity of flow and on the horizontal line for the cross-sectional area most nearly agreeing with that of the stream the number of cubic feet of water per minute will be found.

WEIR METHOD

A weir is a device for measuring flowing water and consists of a vertical wall having at the top a notch through which the water flows.

There are several types of weirs, but the rectangular weir shown in Figure 4 is commonly used for measuring small streams.

The crest or lower edge of the notch of a rectangular weir CD (fig. 4), must be horizontal and the sides AC and BD vertical. It is essential for accurate results that the following conditions be observed.

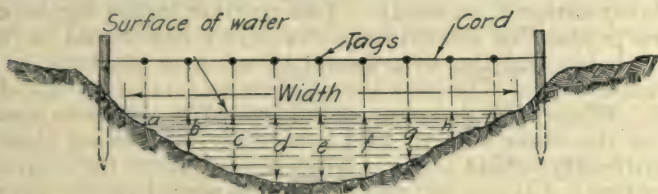


FIG. 3.—Cross-sectioning a stream. Directly under equally spaced points along a cord stretched from bank to bank the depth of water is measured and from these readings the approximate cross-sectional area of the stream may be determined

The length of the notch, AB, should be three to four times the depth of water over the crest. The distance of the ends of the crest from the banks should be at least twice this depth of water and the distance from the stream bed to the crest of the weir should be at least three times this depth of water. To secure these proportions it may be necessary to set a test weir in order to get an idea of the depth of water

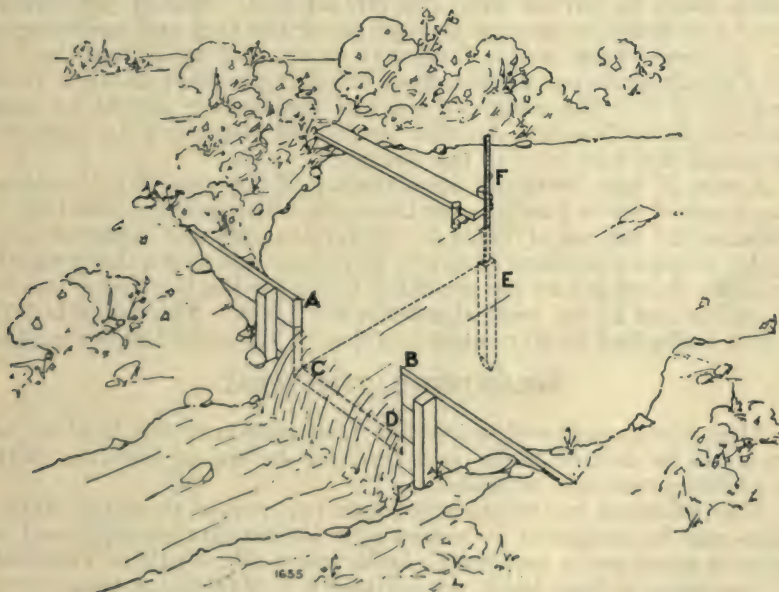


FIG. 4.—Rectangular weir. The type commonly used for measuring small streams

on the weir for the width selected. The tentative width of the notch may first be made two-thirds of the width of the stream at the weir site. The notch should be beveled about 45° to within one-eighth inch of the upstream face, so that the edge will be almost sharp. The water as it flows over the weir should be free to fall without touching the wall

below or any obstruction which might interfere with free circulation of air underneath the falling water. The water above the weir should be practically still and in order to secure this condition it may be necessary to widen and deepen the stream.

The weir should be located, if possible, where fairly large stones are plentiful and where the soil along the banks directly above the weir site is clayey rather than sandy. Two position stakes (fig. 4) should be driven in place, or several large stones or rocks should be planted near each bank, and the weir should be set into the bank so as to bear against them. The weir should then be leveled to the desired position. When the weir is staked and leveled heavy rocks should be placed on the lower side to hold it securely, care being taken that no rocks directly behind the weir notch project above the downstream water surface. Clay or sod should then be placed on the upper side of the weir, beginning at each side and working to the center, until there is no leakage around or under it. Before the water on the upstream side has risen to the level of the weir crest a measuring stake, E (fig. 4), should be driven in the bottom of the pond at a point about six feet above the weir and a carpenter's level used to set the top of the stake level with the crest of the weir. The dam should then be completed so as to force all the water through the notch.

If the bed of the stream is soft, and rocks or stones are not available for anchoring the weir, stakes long enough to hold the weir firmly in place must be driven into the stream bed. Special precautions should be taken to prevent seepage under the dam and undermining on the downstream side. Both may be avoided by setting the weir on a firmly anchored wooden floor extending a short distance above and below it. The ends and sides of the flooring should be made water-tight with sods. Another method of insuring water-tightness is to install a weir box¹ in the stream.

A rule, F, held vertically upon the top of the stake E will indicate the depth of water passing over the crest. The quantity can then be obtained by the use of Table 3. If, for example, the depth of water under normal conditions of flow is $8\frac{3}{4}$ inches on a weir 3 feet long, the quantity in cubic feet per second is found on the horizontal line for $8\frac{3}{4}$ inches and in the vertical column for 3 feet. This figure is 5.97, which multiplied by 60 represents a flow of 358 cubic feet per minute.

MEASURING THE HEAD

After the quantity of water has been measured the head or fall that can be utilized must be determined before an estimate of the available power can be made.

The difference in elevation between two points along the water's edge may be measured by means of a 10-foot straightedge, such as stone masons use, a carpenter's level, and a 2-foot rule or yardstick. If available, a farm level, an engineer's Y level, or a transit with level attachment and a leveling rod should be used, as the work may then be done more rapidly and accurately.

The course of the stream apparently having the greatest fall in the shortest distance is located. One end of the straightedge, at the center of which the carpenter's level should be securely fastened, is

¹ The construction of a weir box is described in Farmers' Bulletin No. 813 "Construction and Use of Farm Weirs."

placed at the water level at the upper end of the stretch. The downstream end is raised until the straightedge is level. The vertical distance between the downstream end of the straightedge and the water surface is the fall in the 10-foot length. The straightedge should then be moved downstream, the upper end being placed at the water surface at the spot where the previous measurement was taken and the operation repeated until the lower point of the selected course is reached. The sum of the vertical measurements will be the total fall.

TABLE 3.—Discharge tables for rectangular weirs

Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths					Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths				
		1 foot	1.5 feet	2 feet	3 feet	4 feet			1 foot	1.5 feet	2 feet	3 feet	4 feet
0.20	2½	0.291	0.439	0.588	0.887	1.19	0.86	10½	2.46	3.72	5.01	7.59	10.19
.21	2½	.312	.472	.632	.954	1.28	.87	10½	2.50	3.79	5.10	7.72	10.36
.22	2½	.335	.505	.677	1.02	1.37	.88	10½	2.54	3.85	5.18	7.85	10.54
.23	2½	.358	.539	.723	1.09	1.46	.89	10½	2.58	3.92	5.27	7.99	10.71
.24	2½	.380	.574	.769	1.16	1.55	.90	10½	2.62	3.98	5.35	8.12	10.89
.25	3	.404	.609	.817	1.23	1.65	.91	10½	2.67	4.05	5.44	8.25	11.07
.26	3	.428	.646	.865	1.31	1.75	.92	11	2.71	4.11	5.53	8.38	11.25
.27	3	.452	.682	.914	1.38	1.85	.93	11	2.75	4.18	5.62	8.52	11.43
.28	3	.477	.720	.965	1.46	1.95	.94	11	2.79	4.24	5.71	8.65	11.61
.29	3	.502	.758	1.02	1.53	2.05	.95	11	2.84	4.31	5.80	8.79	11.79
.30	3	.527	.796	1.07	1.61	2.16	.96	11	2.88	4.37	5.89	8.93	11.98
.31	3	.553	.836	1.12	1.69	2.26	.97	11	2.93	4.44	5.98	9.06	12.16
.32	3	.580	.876	1.18	1.77	2.37	.98	11	2.97	4.51	6.07	9.20	12.34
.33	3	.606	.916	1.23	1.86	2.48	.99	11	3.01	4.57	6.15	9.34	12.53
.34	4	.634	.957	1.28	1.94	2.60	1.00	12	3.06	4.64	6.25	9.48	12.72
.35	4	.661	.999	1.34	2.02	2.71	1.01	12	4.71	6.34	9.62	12.91	
.36	4	.688	1.04	1.40	2.11	2.82	1.02	12	4.78	6.43	9.76	13.10	
.37	4	.717	1.08	1.45	2.20	2.94	1.03	12	4.85	6.52	9.90	13.28	
.38	4	.745	1.13	1.51	2.28	3.06	1.04	12	4.92	6.62	10.04	13.47	
.39	4	.774	1.17	1.57	2.37	3.18	1.05	12	4.98	6.71	10.18	13.66	
.40	4	.804	1.21	1.63	2.46	3.30	1.06	12	5.05	6.80	10.32	13.85	
.41	4	.833	1.26	1.69	2.55	3.42	1.07	12	5.12	6.90	10.46	14.04	
.42	5	.863	1.30	1.75	2.65	3.54	1.08	12	5.20	6.99	10.61	14.24	
.43	5	.893	1.35	1.81	2.74	3.67	1.09	13	5.26	7.09	10.75	14.43	
.44	5	.924	1.40	1.88	2.83	3.80	1.10	13	5.34	7.19	10.90	14.64	
.45	5	.955	1.44	1.94	2.93	3.93	1.11	13	5.41	7.28	11.04	14.83	
.46	5	.986	1.49	2.00	3.03	4.05	1.12	13	5.48	7.38	11.19	15.03	
.47	5	1.02	1.54	2.07	3.12	4.18	1.13	13	5.55	7.47	11.34	15.22	
.48	5	1.05	1.59	2.13	3.22	4.32	1.14	13	5.62	7.57	11.48	15.42	
.49	5	1.08	1.64	2.20	3.32	4.45	1.15	13	5.69	7.66	11.64	15.62	
.50	6	1.11	1.68	2.26	3.42	4.58	1.16	13	5.77	7.76	11.79	15.82	
.51	6	1.15	1.73	2.33	3.52	4.72	1.17	14	5.84	7.86	11.94	16.02	
.52	6	1.18	1.78	2.40	3.62	4.86	1.18	14	5.91	7.96	12.09	16.23	
.53	6	1.21	1.84	2.46	3.73	4.99	1.19	14	5.98	8.06	12.24	16.43	
.54	6	1.25	1.89	2.53	3.83	5.13	1.20	14	6.06	8.16	12.39	16.63	
.55	6	1.28	1.94	2.60	3.94	5.27	1.21	14	6.13	8.26	12.54	16.83	
.56	6	1.31	1.99	2.67	4.04	5.42	1.22	14	6.20	8.35	12.69	17.03	
.57	6	1.35	2.04	2.74	4.15	5.56	1.23	14	6.28	8.46	12.85	17.25	
.58	6	1.38	2.09	2.81	4.26	5.70	1.24	14	6.35	8.56	12.99	17.45	
.59	7	1.42	2.15	2.88	4.36	5.85	1.25	15	6.43	8.66	13.14	17.65	
.60	7	1.45	2.20	2.96	4.47	6.00	1.26	15			13.30	17.87	
.61	7	1.49	2.25	3.03	4.59	6.14	1.27	15			13.45	18.07	
.62	7	1.52	2.31	3.10	4.69	6.29	1.28	15			13.61	18.28	
.63	7	1.56	2.36	3.17	4.81	6.44	1.29	15			13.77	18.50	
.64	7	1.60	2.42	3.25	4.92	6.59	1.30	15			13.93	18.71	
.65	7	1.63	2.47	3.32	5.03	6.75	1.31	15			14.09	18.92	
.66	7	1.67	2.53	3.40	5.15	6.90	1.32	15			14.24	19.12	
.67	8	1.71	2.59	3.47	5.26	7.05	1.33	15			14.40	19.34	
.68	8	1.74	2.64	3.56	5.38	7.21	1.34	15			14.56	19.55	
.69	8	1.78	2.70	3.63	5.49	7.36	1.35	16			14.72	19.77	
.70	8	1.82	2.76	3.71	5.61	7.52	1.36	16			14.88	19.98	
.71	8	1.86	2.81	3.78	5.73	7.68	1.37	16			15.04	20.20	
.72	8	1.90	2.87	3.86	5.85	7.84	1.38	16			15.20	20.42	
.73	8	1.93	2.93	3.94	5.97	8.00	1.39	16			15.36	20.64	
.74	8	1.97	2.99	4.02	6.09	8.17	1.40	16			15.53	20.86	
.75	9	2.01	3.05	4.10	6.21	8.33	1.41	16			15.69	21.08	
.76	9	2.05	3.11	4.18	6.33	8.49	1.42	17			15.85	21.29	
.77	9	2.09	3.17	4.26	6.45	8.65	1.43	17			16.02	21.52	
.78	9	2.13	3.23	4.34	6.58	8.82	1.44	17			16.19	21.74	
.79	9	2.17	3.29	4.42	6.70	8.99	1.45	17			16.34	21.96	
.80	9	2.21	3.35	4.51	6.83	9.16	1.46	17			16.51	22.18	
.81	9	2.25	3.41	4.59	6.95	9.33	1.47	17			16.68	22.41	
.82	9	2.29	3.47	4.67	7.08	9.50	1.48	17			16.85	22.64	
.83	9	2.33	3.54	4.75	7.21	9.67	1.49	17			17.01	22.85	
.84	10	2.37	3.60	4.84	7.33	9.84	1.50	18			17.17	23.08	
.85	10	2.41	3.66	4.92	7.46	10.01							

The head may also be measured by using two poles, a straightedge, and a carpenter's level, as indicated in Figure 5. The poles should be several feet long with feet and tenths of feet marked on them. Suppose the difference in elevation between points A and B (fig. 5) is desired. A straightedge, to which a carpenter's level has been fastened, is placed against the poles set in positions 1 and 2. When the level bubble has been brought to the center of the tube, suppose the leveling piece is at the 4-foot mark on the lower and the 2-foot mark on the upper, then the difference in elevation between points A and C will be 2 feet. The first pole is then moved upstream to position 3 and the leveling is repeated. The straightedge may be placed at any height and the difference in the readings at the poles will be the rise in the ground between them. When the series of measurements has been completed, the sum of all the differences will be the total difference, or the head between A and B. Whichever method is used the

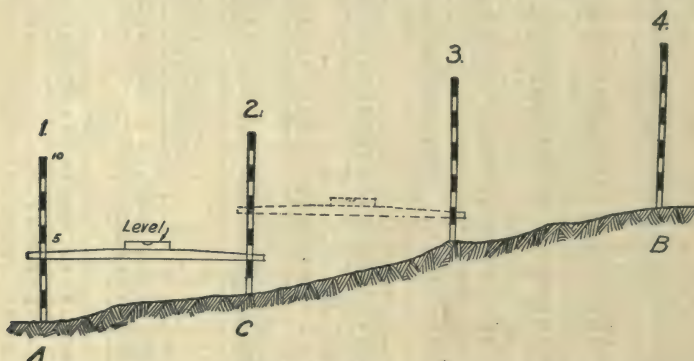


FIG. 5.—The difference in elevation between two points may be determined by using two poles and a carpenter's level as described in the text

measurements should always be taken twice as a check on the accuracy of the work.

If the head found is not sufficient to produce the power needed so that a dam is required, then the point upstream to which the back-water would extend from a dam of a given height can be found by repeating the leveling process until a point is reached that corresponds to the total difference in elevation between A and B plus the additional height required for the dam.

WATER-POWER ELECTRIC PLANTS

The essential characteristics of a water-power electric plant will vary according to conditions at the contemplated site and the demands which the plant must meet. Plants are often designated according to the type of water motor used to drive the generator. Figures 6 and 7, respectively, illustrate the general characteristics of an over-shot wheel and a turbine installation. Different types and sizes of water turbines and water wheels are used to suit various conditions of head and flow.

In general it is not advisable to attempt to develop a water-power plant unless the available power is equivalent to that developed by a flow of 30 cubic feet per minute acting under a 10-foot head. If the



FIG. 6.—Farm water-power electric plant with overshot water wheel. A, transmission line; B, power house; C, generator; D, switchboard; E, storage battery; F, flume; G, head gate; H, forebay; I, tail-water; J, tailrace; K, electric line, generator to switchboard; L, water supply control gate; M, overshot water wheel

power is less than that derived from a flow of 100 cubic feet per minute with a 10-foot head, a storage battery is usually necessary. The cost of a battery increases with the voltage required. The maximum



FIG. 7.—Farm water-power electric plant with water turbine. A, transmission line; B, power house; C, generator; D, switchboard; E, water turbine; F, flume; G, head gate; H, forebay; I, tailrace; J, stream

distance that a 32-volt current can be carried economically is about 300 feet. This should be kept in mind in selecting the site for the plant. If the current has to be carried more than 300 feet it may be advisable to install a 32-volt battery and generate current at 40 to 65 volts

so as to compensate for the high voltage drop due to the greater distance, or it may even be necessary to adopt a 110-volt current.

The 32-volt plant requires a battery of 16 lead cells or 26 nickel-iron cells; 56 lead or 92 nickel-iron cells are needed for a 110-volt plant. The approximate cost of cells varies from \$5 to \$8, depending upon the size and make; hence for a 110-volt battery the cost of the plant will be materially increased. Storage batteries have definite requirements for charging and expert advice should be obtained, so that generator and battery will harmonize. Unless this is done damage may result.

A storage battery consists essentially of one or more cells each composed of two metal plates known, respectively, as positive and negative, with an insulating separator between them, immersed in a liquid called the electrolyte, and all incased in a rubber, glass, or metal container. Storage batteries are of two types, the lead-acid and the nickel-iron alkaline. In the lead plate type the grids or plates are of lead in acid electrolyte, while in the nickel-iron type they are of steel in an alkaline electrolyte. A steel container is used for the nickel-iron cell, the lead-acid container being of rubber or glass. The average voltage of a lead battery when discharging at its normal rate is 2 volts per cell, while each cell of a nickel-iron battery has a voltage of 1.2 volts. In either case the battery voltage is that of one cell multiplied by the number of cells. The capacity of a battery is stated in ampere-hours. A battery whose capacity is 1 ampere-hour will empty a full charge in 1 hour at the rate of 1 ampere or, if the capacity is 120 ampere-hours, it will be capable of supplying current at the rate of 2 amperes for 60 hours or 10 amperes for 12 hours continuously. The nickel-iron battery is preferable to the lead battery. Its cost for the same capacity is considerably greater, but it is less liable to damage due to overcharging or handling and it will last many years longer.

DAMS

If the continuous flow is great enough and the drop is sufficient to give the required head, a small diversion dam will suffice. This may consist of a large tree trunk planted between projecting rocks, with loose stones and earth to stop underflow and to direct the water into the flume conducting the water to the motor. When it is necessary to raise the water level only a few inches or perhaps a foot, temporary dams may be employed. These may consist of sandbags placed across the streams or bundles of brush weighted or staked down, or stones and a few boards. Such dams will leak, sometimes profusely, and may be washed out by a freshet, yet they are often practicable because the cost of renewing them is almost nothing.

If the stream flow is too small for continuous operation, so that it is necessary to store the water for a time in order to have enough to drive the motor for a short period, a substantial dam will be needed. A permanent dam requires careful design and workmanship. It may be built of earth, wood, brush, stone, concrete, or steel, or a combination of two or more of these materials.

The effect of backwater upon adjoining land should be considered carefully so as to avoid trouble resulting from damage to property.

Earth dams are not recommended. If circumstances make it desirable to build this type of dam, it should be built so that water will not flow over it, since this would be almost certain to cause its failure. Accordingly it should be provided with a spillway of sufficient size to pass the entire flow of the stream during floods. This should be located, if possible, at one side of the dam and should be lined with concrete or boards to prevent scouring. Before attempting to build an earth dam expert advice should be obtained from the State agricultural college, the United States Department of Agriculture, or other reliable source.

The crib dam (figs. 8 and 9) consists of rough and green logs or sawed timbers placed across one another at intervals of 2 or 3 feet and spiked together, the spaces between being filled with stones. The upstream side is covered with planks nailed in place to prevent leakage, and sometimes the downstream face is likewise covered so as to direct the flowing water away from the dam and prevent it from leaking back into the cribbing. Crib dams are sometimes built of logs of different lengths arranged so as to form a series of steps on the downstream side to break the force of the falling water.

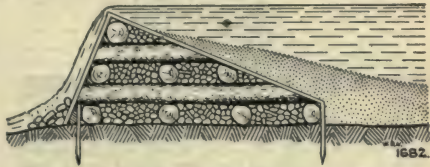


FIG. 8.—Crib dam. For heads not exceeding 6 feet, timbers, placed across one another at intervals of 2 or 3 feet and spiked together, provide substantial construction

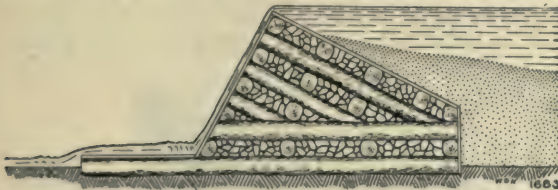


FIG. 9.—Crib dam. This construction is recommended for dams more than 6 feet high

2 by 6 inch rough, sound lumber, free from sap and sharpened by sawing diagonally across one end. They should be driven firmly into the stream bed and spiked to the crib logs.

If a crib, concrete, or masonry dam is built on bedrock, a rough surface is better than one that is too smooth, as a rough surface prevents possible sliding of the dam on its foundation.

While satisfactory small masonry or concrete dams are often built without the aid of technical advice, such advice usually results in the saving of material and labor. Cut stones or brick should never be used, as a more stable dam can be made by the use of rubble masonry.

If rock is plentiful near the dam site, a substantial masonry dam having its base equal to eight-tenths its height may be built of uncut stones laid in cement mortar. Figure 10 shows the section of a small

Priming planks (see fig. 8) are driven into the stream bed in a row on both the upstream and downstream side to prevent water from seeping under the dam.

Priming planks may be made from

masonry dam. If the dam is to be as high as 12 feet, it should not be attempted without the advice of a competent engineer as to design, type, and footing. Even a stream bed of solid rock which appears perfectly safe may be so porous as to threaten the stability of a dam.

Concrete is generally more easily handled than masonry, and its use

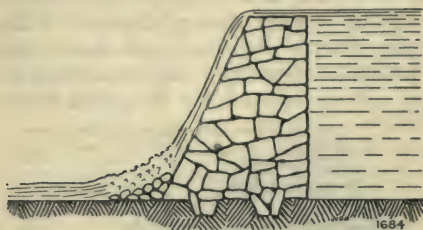


FIG. 10.—Masonry dam. Dams not more than 10 feet high may be built of uncut stones laid in cement mortar. The width of the base should be at least eight-tenths of the height

They should be well surrounded by mortar and their total volume should not exceed 30 per cent of the volume of the dam. This dam should not be used for a length greater than 50 feet.

TABLE 4.—Dimensions of sections for gravity concrete dams. See Figure 11

A Height of dam	B	C	D	E	F	Quantity of con- crete per foot of width (approx- imate)
<i>Feet</i>	<i>Ft. in.</i>	<i>In.</i>	<i>Ft. in.</i>	<i>Ft. in.</i>	<i>Ft. in.</i>	<i>Cu. ft.</i>
3	1 0	3	1 0	0 9	5 0	10
4	1 3	3	1 0	0 9	6 0	15
5	1 6	3	1 3	0 11	7 3	22
6	1 9	3	1 6	1 1	8 6	31
7	2 0	3	1 9	1 3	9 9	41
8	2 2	3	2 0	1 6	11 0	53
9	2 7	3	2 3	1 9	12 6	67
10	3 0	3	2 6	2 0	14 0	84

THE FLUME

A flume is employed to conduct the water to the water wheel or turbine. The length of the flume will depend upon the topography adjacent to the dam or power site. It may be more economical to construct a long flume in order to secure a sufficient head of water between the dam and power house than to build a high dam with a comparatively short flume. Generally, low diversion dams with long earth flumes are preferable for small stream developments where the slope of the land is gradual enough to permit of this type of flume and of building the power house at a desirable location. If the land falls rather abruptly, the flume may consist of an open, wooden trough supported as shown in Figure 12. If the flume is as much as 4 feet wide, it may be built of 2-inch tongued-and-grooved planks and rested on 3 by 4 inch mudsills laid on the ground which has been

² Farmers' Bulletin 1279, "Plain Concrete for Farm Use," contains instructions for preparing and handling concrete.

previously cleared and leveled. Open, rectangular, continuous, wood trough flumes (see fig. 13) 4 feet wide or wider should be braced with 3 by 4 inch studs with three-fourths-inch tie bolts at top and bottom. Wood stave pipe is often used for the flume (see fig. 14), while riveted steel pipe may be required where the head is high. If a pipe line is used, due consideration must be given to the friction head loss. The size of pipe that should be used depends upon the quantity of water that it is to carry and the length of the line.

HEAD GATES

Head gates, by means of which the supply of water to the water wheel may be cut off, should be located at the entrance to the channel or flume. The multiple bulkhead gates shown in Figure 15 are more easily opened and closed than a single large gate. It is often advisable to place trash racks or screens just in front of the gates to protect the

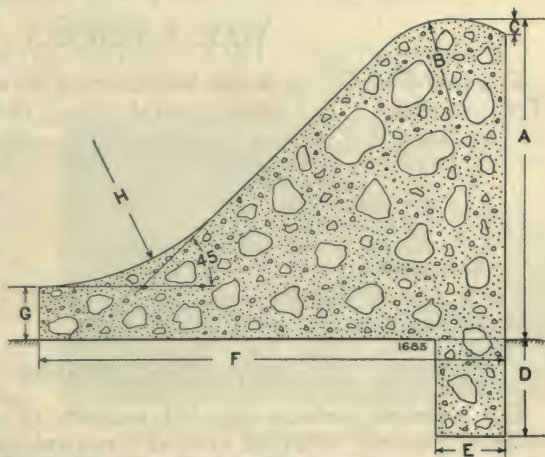


FIG. 11.—Concrete gravity dam. Being generally more easily handled than masonry, the use of concrete is common in dam construction. For dimensions see Table 4



FIG. 12.—Small, open, wood trough flume. Properly supported this is a substantial and relatively cheap construction

turbine or wheel. Trash racks are more necessary for turbines than for overshot wheels. They keep out leaves which are apt to become troublesome in the fall of the year, and protect against light trash and ice. Homemade racks are frequently very efficient, but the commercially built rack is apt to be stronger and to permit more water to pass when there is a mass of débris. The trash rack should be designed with regard to the peculiarities of the particular canal, flume, or penstock, and should be set at the angle best suited to the conditions.

A closed pipe through which the water flows under pressure to the motor, as shown at F in Figure 7, is called the penstock. An open

trough used for the purpose is called a flume. A small body of water at the entrance to a penstock or flume is usually called the forebay or headwater. The tailwater is water that has been discharged from the water motor. The channel or trough through which the water is conducted downstream is called the tailrace.

WATER WHEELS

The power of falling water is converted to use through some type of water wheel. The three general classes of wheels are as follows:

1. Reaction or pressure wheels (reaction turbine).
2. Gravity or current wheels, which include:
 - (a) Undershot wheels.
 - (b) Breast wheels.
 - (c) Overshot wheels.
 - (d) Pitch-back or high breast wheels.
3. Impulse or velocity wheels (Pelton).

The overshot, impulse, and reaction wheels are the types generally used for small water-power installations.

REACTION TURBINES

The reaction turbine (fig. 16) consists of a number of curved vanes or runners arranged around a central shaft to which they are



FIG. 13.—Large, open, wood trough flume. Wood flumes of heavy construction should rest upon mudsills laid on the ground, previously cleared and leveled, and should be well braced at top and bottom with 3 by 4 inch studs and tie bolts.

rigidly connected. The water in flowing through these vanes causes the wheel to rotate. The shaft may be either vertical or horizontal. In addition to the runners the equipment includes the guiding elements and the gate which regulates the supply. The function of the gate is to direct the water to the runners in the proper manner. Swing gates are pivoted guide vanes which act as gates. Another type of gate is the cylinder, which is the cheaper construction but less efficient when partly closed. The power of the wheel is developed by the reaction or pressure of the water as it leaves each blade.

The turbine is controlled by a fly-ball governor, which operates to close the gate if the load is reduced or to open it if the load is increased.

Turbines may be mounted in wood or concrete inclosures or in iron or steel cases connected with the penstock. Figure 17 shows a vertical turbine mounted in a wooden flume, the power being transmitted through bevel gears.

The turbine is generally used for medium and low heads and comparatively large quantities of water. Stock turbines can usually be obtained for heads varying from 2 to 80 feet; they are specially designed for higher heads. The efficiency of the smaller sizes is about 70 to 80 per cent with gates wide open.

OVERSHOT WHEELS

The overshot wheel (fig. 18) is suited to heads varying from 4 to 60 feet, but if the head exceeds 20 feet the cost for small installations may be prohibitive. The efficiency of modern steel overshot wheels is 80 to 90 per cent. Wooden overshot wheels are still used to some extent. They cost less than steel wheels, but their life is shorter and their efficiency is lower.

Regulation of overshot wheels is necessary to prevent sudden changes in speed due to variation in load. This is accomplished by means of a fly-ball governor which regulates the water gate according to power requirements. By proportioning the opening of the water gate to the load on the wheel only the water actually required is released while the remainder is conserved. Conservation of water and regulation of speed are essential to the proper operation of small water-power electric plants.



Fig. 15.—Multiple bulkhead flume gates. The smaller units are far easier to operate than a single large gate, and if tightly built will insure equally good stoppage of water

In the State of Virginia alone more than 1,000 mills and factories are driven by this type of water wheel.

IMPULSE WHEELS

The impulse wheel (fig. 19) is popularly known as the Pelton wheel. It is especially suited for use in mountain sections where the quantity of water is small and the head relatively high or where springs issue from high hillsides. The flow of a small spring may be stored behind an earth dam during the day and operate the wheel at night to generate current for electric lights.

The wheel consists of an iron frame mounted on a horizontal shaft with cup-shaped buckets attached to the rim (fig. 20). The water flows to the wheel through a pipe under pressure. A nozzle at the

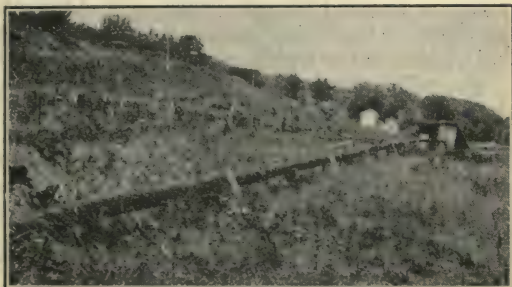


Fig. 14.—Wood stave pipe flume. This type may be quickly installed, but is expensive, especially in the larger sizes

end of the pipe directs a jet of water against the buckets, thus turning the wheel.

If the load varies considerably, the speed of the wheel must be governed. In the smaller installations the adjustment for changes of load for short periods is usually made by deflecting the jet of water away from the buckets when the speed becomes excessive. This method wastes water and hand regulation is sometimes preferable. In the larger installations an automatic governor slowly actuating a needle valve provides adjustment for gradual changes of load, and a deflector is used to take care of sudden changes. It is inadvisable to cut off or suddenly reduce the flow in the pipe, since quick stoppage will cause water hammer and may burst the pipe.

The efficiency of the modern impulse wheel is about 80 per cent. It is sold for heads as low as 20 feet but is ordinarily used for heads of over 100 feet. There is apparently no upper limit to the head under which the wheel may operate.

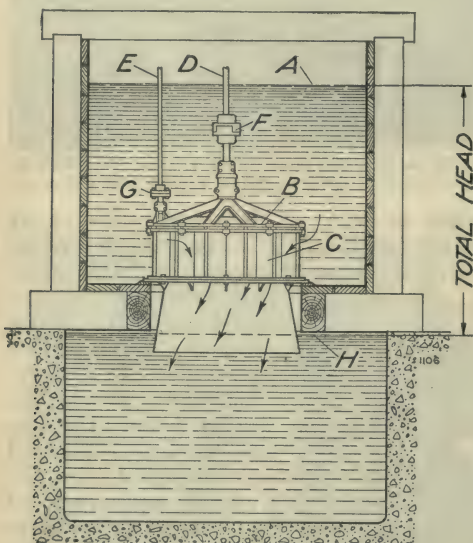


FIG. 16.—Vertical reaction turbine in wooden pit. A, headwater level; B, water turbine; C, wicket guide gates; D, turbine shaft; E, gate control shaft; F, jaw coupling; G, flange coupling; H, tail-water level

TURBINE AND WATER WHEEL CONNECTIONS

A generator or other machinery may be connected to a water motor by means of spur or bevel gears, pulleys and belts, a combination of gears, pulleys, and belts, or when the water-motor speed is practically the same as the required generator speed the two may be direct connected through the same shaft. Owing to the relatively high speed of generators, a belted arrangement will almost invariably be necessary. Gearing may be required in conjunction with the belting, especially where

the power generated is sufficient to drive a line shaft from which other machinery may also be driven. Gear transmission is more positive than the belt drive. Efficiencies are about the same so long as the belt is kept in proper condition as to tension, softness, and pliability, and the gearing is kept well lubricated. Belts gradually stretch and provision should be made for tightening them. A satisfactory arrangement is to install a sliding base generator. Generator speeds usually require that the water-motor speed be stepped up considerably. To do this by gearing alone is seldom feasible, owing to the number of pairs of gears required in order to avoid excessively large sizes and the expense incident thereto. The same result usually can be secured by belting with a fairly large pulley on the turbine shaft and a small pulley on the generator shaft. The arrange-

ment of connections must be designed to suit the particular installation. It is not possible to show in this bulletin the many different connections that may be used. In figures 17 and 20 to 29, inclusive, are illustrated a few of the common methods employed.

COMPARISONS OF TURBINE AND OVERSHOT WHEELS

The wheel selected should be suited to the power site, and a careful study of the situation should be made before deciding which type to install.

The flow of all streams varies considerably, and the power plant should be designed to operate on the minimum flow, unless there is provision for storing water to supplement the low flow. For variable stream flow the overshoot wheel is ideal. If designed for normal stream flow, it will still deliver a high percentage of the available power during low stream flow; in fact the efficiency of the overshoot wheel is slightly higher at low water than at normal periods, because when the buckets are only partially filled the water is carried to a lower level before spilling. The efficiency of a turbine wheel falls rapidly as the supply of water is reduced. An overshoot wheel may be used where the flow is insufficient for a turbine wheel, and will therefore provide power for lights and small home conveniences during dry months, and additional power for operating wood saws and other stationary machinery when water is plentiful, while under low-water conditions the quantity might be insufficient to operate a turbine. The overshoot wheel is less likely to become clogged with trash and is more efficient than the turbine wheel.

The turbine wheel occupies less space than the overshoot wheel, and this may sometimes be an advantage. It sets low and may be operated on storage water under a head as low as 75 per cent of the total

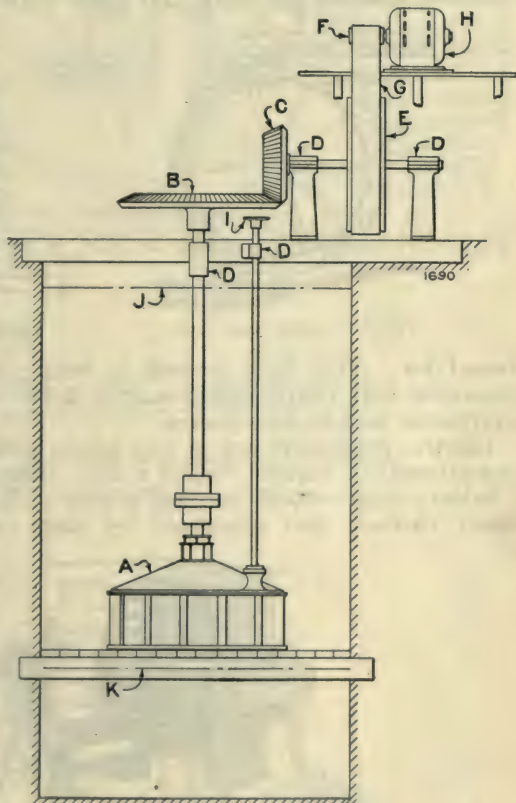


FIG. 17.—Vertical reaction turbine with hand control for driving a small generator through bevel gears and belted pulleys. Where streams are subject to flood, the generator should be set high in order to avoid possible damage from water soaking. A, turbine; B, bevel gear; C, bevel pinion; D, bearing; E, drive pulley; F, generator pulley; G, belt; H, generator; I, hand gate control; J, headwater level; K, tail-water level

head, whereas the overshot wheel can not use water from the storage reservoir below the level of the top of the wheel. The turbine runs at higher speed, which is an asset when it is to drive an electric generator. It will operate submerged. Its cost for the power developed is usually lower than that of the overshot wheel, due principally to the fact that overshot wheels are generally built specially for each installation, while turbines of various sizes are usually carried in stock.

ELECTRIC POWER

Electricity passes through metallic wires or conductors in a manner somewhat analogous to water flowing through pipes. The unit of electrical power is the watt, and 1,000 watts make 1 kilowatt, abbre-

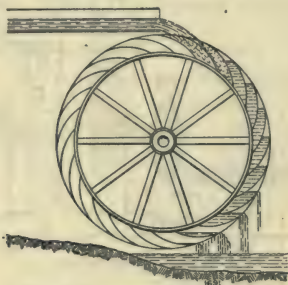


FIG. 18.—Overshot water wheel

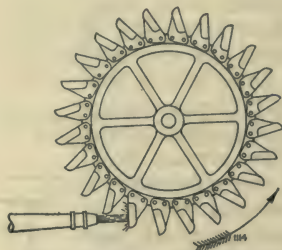


FIG. 19.—Impulse water wheel

viated kw. This term is used in rating generators; thus a 2-kw. generator will continuously supply 2,000 watts. One kilowatt is equivalent to 1.34 horsepower.

Electric generators are of two kinds, direct current (called d. c.) and alternating current (called a. c.). The electricity obtained from a battery or generated by small plants such as are here considered is direct current; that generated by large central stations and dis-

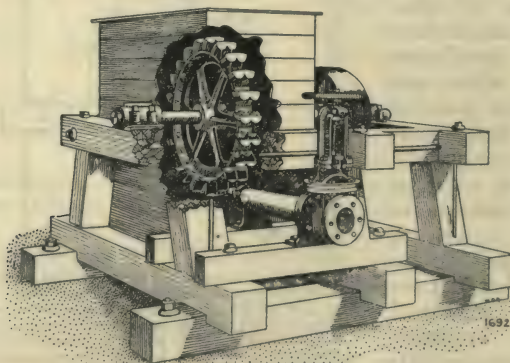


FIG. 20.—Typical impulse water wheel installation with drive pulley

tributed to considerable distances is mainly alternating current. Direct current is used as it flows from the generator at comparatively low voltage, 32 or 110 volts, whereas alternating current is generated and flows in the distribution system at high voltage, 6,600 to 11,000 volts and higher. This high-pressure electricity is reduced by means

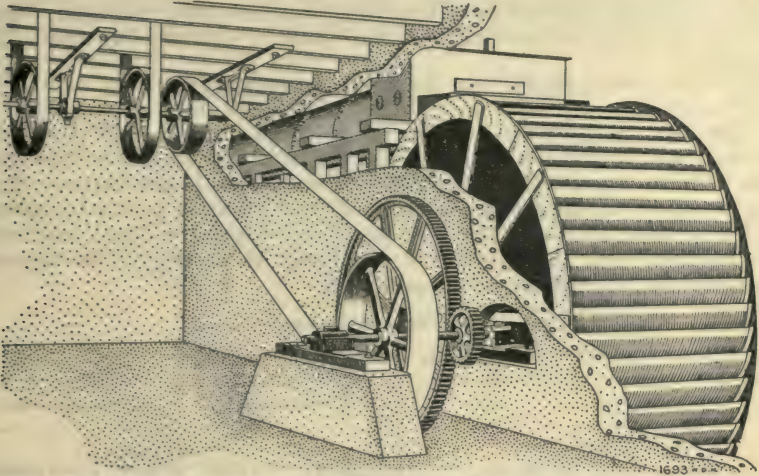


FIG. 21.—Typical overshot water-wheel installation with master spur gear keyed to water-wheel shaft inside the building. A bevel, instead of spur gear, is used if the driven shaft is at right angles to the wheel shaft. Power for driving the generator and other machines is transmitted through the pinion shaft to belted pulleys

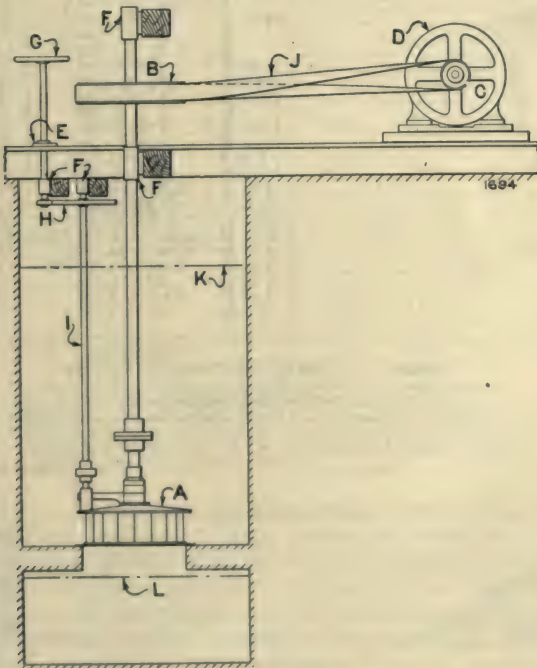


FIG. 22.—Vertical reaction turbine belted direct to generator with hand control. A, turbine; B, drive pulley; C, generator pulley; D, generator; E, ratchet and pawl; F, bearing; G, handwheel control; H, gears; I, gate shaft; J, belt; K, headwater level; L, tail-water level

of a transformer located near the point of application. For lighting purposes either direct or alternating current may be used, but a motor can only be operated by the kind of current for which it is designed.

SIZE OF PLANT REQUIRED

The size of the plant should be determined with regard to both present and future needs. Too much emphasis can not be laid upon the wisdom of providing for a plant of somewhat larger capacity than the needs of the moment seem to indicate if ample power to operate it is available. One or two additional horsepower will not add much to the first cost, and more power is likely to be desired as the conveniences of electricity are appreciated.

TABLE 5.—*Uses of electricity for power*

[Trade data on power requirements]

Device	Power required		Most popular size	
	Horse-power	Watts	Motor horse-power	Watts consumed
Washing machine.....	$\frac{1}{8}$ to $\frac{1}{4}$	165 to 290	$\frac{1}{4}$	290
Vacuum cleaner.....	$\frac{1}{8}$ to $\frac{1}{2}$	165 to 535	$\frac{1}{8}$	210
Electric fan, 8-inch.....	$\frac{1}{10}$	50	$\frac{1}{10}$	50
Electric fan, 16-inch.....	$\frac{1}{12}$	125	$\frac{1}{12}$	125
Sewing machine.....	$\frac{1}{10}$	50	$\frac{1}{10}$	50
Dish-washing machine.....	$\frac{1}{8}$ to $\frac{1}{4}$	165 to 290	$\frac{1}{4}$	290
Ironing machine.....	$\frac{1}{12}$	290	$\frac{1}{4}$	290
Ice-cream freezer.....	$\frac{1}{2}$	535	$\frac{1}{2}$	535
Separator.....	$\frac{1}{8}$ to $\frac{1}{4}$	165 to 290	$\frac{1}{6}$	210
Churn.....	$\frac{1}{2}$ to 3	165 to 2,640	$\frac{1}{4}$	290
Milk tester.....	$\frac{1}{12}$ to $\frac{1}{8}$	125 to 165	$\frac{1}{8}$	165
Root cutter.....	$\frac{1}{4}$	290	$\frac{1}{4}$	290
Horse and sheep clippers.....	$\frac{1}{6}$ to $\frac{1}{4}$	210 to 290	$\frac{1}{4}$	290
Grindstone.....	$\frac{1}{6}$ to $\frac{1}{4}$	165 to 290	$\frac{1}{4}$	290
Milking machine.....	1 to 3	932 to 2,640	3	2,640
Corn sheller.....	$\frac{3}{4}$ to $1\frac{1}{2}$	746 to 1,400	1	990
Feed grinder.....	3 to 10	2,640 to 8,300	5	4,380
Emery wheel.....	$\frac{1}{4}$ to 1	290 to 932	$\frac{1}{4}$	290
Lathe.....	$\frac{1}{4}$ to $\frac{1}{2}$	290 to 535	$\frac{1}{2}$	535
Silage cutter.....	10 to 25	8,300 to 20,700	15 to 20	12,400 to 16,600
Shredder and husker.....	10 to 20	8,300 to 16,600	15	12,400
Concrete mixer.....	2 to 10	1,864 to 8,300	5	4,380
Refrigeration.....	$\frac{1}{2}$ to 10	535 to 8,300	5	4,380
Cordwood saw.....	3 to 10	2,640 to 8,300	5	4,380
Pump, water.....	$\frac{1}{2}$ to 5	535 to 4,380	3	2,640

TABLE 6.—*Uses of electricity for heating*

[Trade data on power requirements]

Device	Power required	Average size used consumes—
	Watts	Watts
Electric flatiron.....	500 to 600	550
Electric toaster.....	350 to 500	450
Chafing dish (3-pint).....	400 to 600	500
Coffee percolator (9-cup).....	400 to 420	420
Waffle iron.....	600	600
Milk warmer (nursing bottles).....	200 to 500	300
Hot plate.....	220 to 1,000	500
Curling iron.....	15 to 40	30
Warming pad.....	30 to 50	40
Bake ovens.....	600 to 1,800	1,500
Fireless cooker.....	500 to 660	600
Water heater (kitchen boiler).....	500 to 3,000	2,500
Range.....	2,500 to 5,000	2,500

Electricity is used on the farm for light, power, and heat. Usually the first requirement is to light the buildings and driveways, and many small streams are capable of furnishing sufficient power to provide electricity for this purpose.

The uses of electricity for power and heating, together with the power requirement of each of a number of machines, are listed in

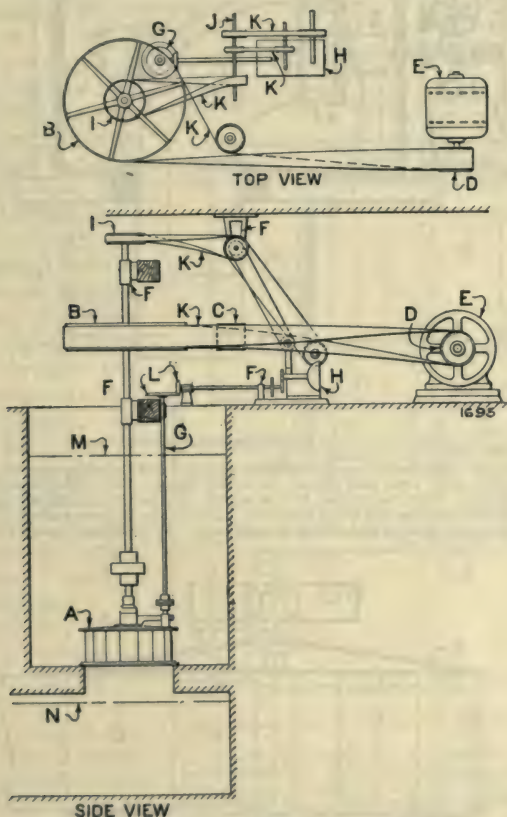


FIG. 23.—Vertical reaction turbine belted direct to generator with automatic governor control. A, turbine; B, drive pulley; C, idler pulley; D, generator pulley; E, generator; F, bearing; G, gate control shaft; H, governor; L, governor drive pulley; J, countershaft for governor drive; K, belts; L, bevel gears; M, headwater level; N, tail-water level

Tables 5 and 6. An electric cooking range is probably the largest single heating load that most farm plants are capable of handling. House heating by electricity is an expensive luxury even when current is obtained from a large hydroelectric plant. Therefore the heating of a house from a farm electric plant should not be considered, although a small electric heater might be used in the bathroom or other small room to take off the chill in the morning.

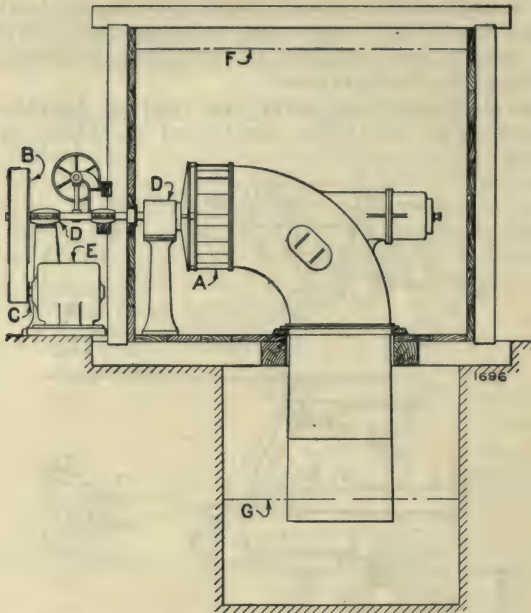


FIG. 24.—Horizontal reaction turbine mounted in a cast-iron quarter-turn draft tube and placed in timber-flume. This arrangement permits direct connection to a generator, or a pulley may be placed on the shaft for belt drive as shown. A, turbine; B, drive pulley; C, generator pulley; D, bearing; E, generator; F, headwater level; G, tail-water level

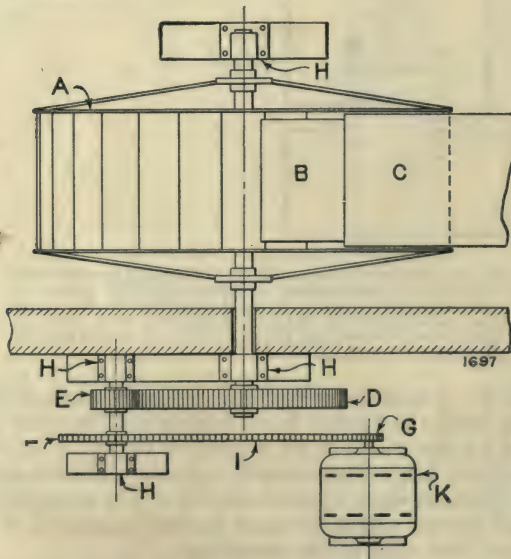


FIG. 25.—Overshot water wheel with roller chain drive. Where space does not permit belt drive and the line shaft is too far away for gear drive from the jackshaft, the difficulty may be overcome in this manner. A, water wheel; B, chute; C, flume; D, drive gear; E, pinion gear; F, drive sprocket; G, generator sprocket; H, bearings; I, roller sprocket chain; K, generator

By means of Figure 30 the number of lights required to illuminate a particular area may be determined as follows: Suppose the floor area of a living room is 288 square feet. This area is found on the scale on the left side of the chart. Following over horizontally to the radiating line for the living room, the figure at the bottom or top of the first vertical line to the right of this intersection indicates the number and size of lamps required for the most efficient use of current. The heavy line shows that for 288 square feet four 40-watt lamps are required, a total of 160 watts. The floor area of all other spaces to be illuminated and the wattage required should be similarly determined.

The lighting power and heating loads vary for every farm. In Tables 7, 8, and 9 are listed various items of electrical household and power equipment in an assumed liberally equipped farm installation with the number of watts required to operate each unit. In making an estimate of the watt requirements on any particular farm similar tables based on the data contained in Figure 30 and Tables 5 and 6 should be prepared.

It is more than probable that but a portion of the equipment listed in each of Tables 7, 8, and 9 will ever be in use at the same time. In determining the size of plant required those items of equipment in each table which are likely to be in

use at one time should be listed and the wattage required for their operation totaled. It may be assumed that but $33\frac{1}{3}$ percent of the house lamp wattage and 20 per cent of the outbuilding lamp wattage will ever be used at one time.

Thus in preparing an estimate for this assumed installation the total lighting load would be 644 watts, as indicated in Table 7. Assuming that, of the larger power units listed in Table 8, the washing machine, dish washer, water pump, and corn sheller might be in use at the same time, the power wattage required would be 3,435. In addition the electric range and the percolator (Table 9) might also be in use, adding 2,920 to the required wattage, the total then being 6,355 watts, necessitating a 7-kw. plant. If a plant of this size is not feasible, a smaller one may be installed together with the same items of equipment, provided care is taken that only units whose combined wattage requirements do not exceed the capacity of the plant are used at the same time.

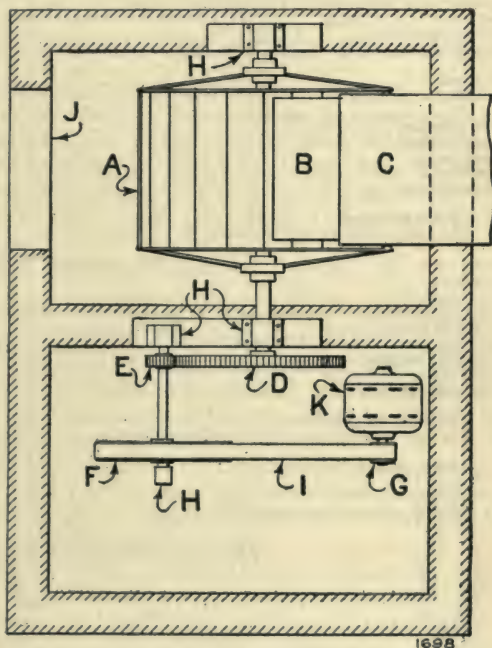


FIG. 26.—Overshot water wheel installation for driving a slow-speed generator. Note small number of gears and pulleys for stepping up the speed of the water-wheel shaft and compare with Figure 27. A, water wheel; B, chute; C, flume; D, drive gear; E, pinion gear; F, drive pulley; G, generator pulley; H, bearing; I, belt; J, discharge outlet; K, generator

TABLE 7.—Sample lighting estimate

Location of lamps	Area of space to be lighted, square feet	Lamps		Total watts	Simultaneous load
		Number	Size		
Living room.....	285	6	25	150	
Dining room.....	196	5	25	125	
Bedroom (first floor).....	200	3	40	120	
Kitchen.....	167	5	25	125	
Laundry and wash room.....	120	2	25	50	
Bath.....	55	2	25	50	
Hall (downstairs).....	56	1	25	25	
Storage pantry.....	28	1	25	25	
Cellar.....	456	3	25	75	
Bedroom.....	232	3	40	120	
Do.....	166	2	40	80	
Do.....	200	3	40	120	
Hall (upstairs).....	85	1	25	25	
Porch (front).....	216	1	40	40	
Porch (side).....	228	1	40	40	
Porch (rear).....	210	1	40	40	
Miscellaneous.....				160	
Total for house.....				1,370	
Per cent total watts in use at one time, 33½ per cent.....					457
Horse barn.....	1,000	8	25	200	
Cow barn.....	700	6	25	150	
Hog house.....	400	4	25	100	
Chicken house ¹	200	5	25	125	
Watering trough.....	100	1	40	40	
Front gate.....	100	1	40	40	
Barnyard entrance.....	100	1	40	40	
Dairy house.....	160	2	40	80	
Miscellaneous.....	160			160	
Total for outbuildings.....				935	
Per cent total watts in use at one time, 20 per cent.....					187
Total lighting load.....					644

¹ Lights to stimulate egg production.

TABLE 8.—Sample power estimate

Purpose	Horse-power of motor (Table 5)	Watts required (Table 5)	Simultaneous load
Washing machine.....	¼	290	
Vacuum cleaner.....	⅓	165	
Sewing machine.....	⅓	50	
Dishwasher.....	¼	290	
Ironing machine.....	¼	290	
Total for house.....		1,085	
Maximum watts required at one time.....			580
Separator.....	⅓	210	
Churn.....	¼	290	
• Corn sheller.....	1	990	
Lathe.....	½	535	
Grindstone.....	¼	290	
Milking machine.....	3	2,640	
Water pump.....	2	1,865	
Total farm uses.....		6,820	
Maximum watts required at one time.....			2,855
Total power load.....			3,435

TABLE 9.—Sample heating estimate

Device	Watts (Table 6)	Simulta- neous load
Electric flatiron.....	550	
Electric toaster.....	450	
Coffee percolator.....	420	
Hot plate.....	500	
Electric range.....	2,500	
Total.....	4,420	
Maximum in use at one time.....		2,920

AVAILABLE POWER SITES ON SELECTED STREAMS

Preliminary surveys were made on three typical streams in Virginia to obtain data with regard to the possibilities of small-stream development and to select sites for power plants from which electricity for light and power could be obtained for farms located near by. The streams surveyed were Cripple Creek in Wythe County, Mill Creek in Montgomery County, and Buchanan Creek in Washington County.

CRIPPLE CREEK PROJECTS

Figure 31 shows the section of Cripple Creek along which available power sites were located. Within a distance of 1.6 miles from the source, six sites are indicated. Each location requires different treatment owing to variations in the quantity of water available, the heads, and the surrounding conditions, but each site is more or less typical of those on many small streams.

Site No. 1.—Located near the source of the stream where the water supply was but 105 cubic feet per minute and the useful head $5\frac{1}{2}$ feet, this site presents a typical small-stream condition. There is too little energy to supply electric current direct from the generator, so that a storage battery must be used. Since there is a dam already in place, the installation of a water wheel, small generator, and storage battery would provide a plant that would compare favorably with a good engine-driven outfit of equal capacity at an estimated cost of about \$750³ with a nickel-iron battery, or of about \$600 if a lead-plate battery were used.

Site No. 2.—On this site an overshot water wheel now operates a flour mill intermittently on stored water. Further use of the water could be made by installing a small generator and storage battery which would operate simultaneously with the mill and not interfere therewith. It would provide electricity for lighting nearby homes at a reasonable cost and give the owner a satisfactory return on his investment.

Site No. 3.—A spring flowing 300 cubic feet per minute empties into a natural reservoir. A dam 4 feet high across the outlet of the creek would make possible a continuously operated plant of 1-kw. capacity without a storage battery, or the equivalent of the average farm-lighting plant. A higher dam would make possible a plant of greater capacity.

³ In estimating the costs of this and the following projects no labor charge is included, it being assumed that the work will be done by farm help at times when not otherwise employed. It is further assumed that no expense for technical advice is to be incurred.

Site No. 4.—The additional water from a spring below site No. 3 and the topography of the land offers an opportunity to supply one home with electricity for lighting and small power units, or three near-

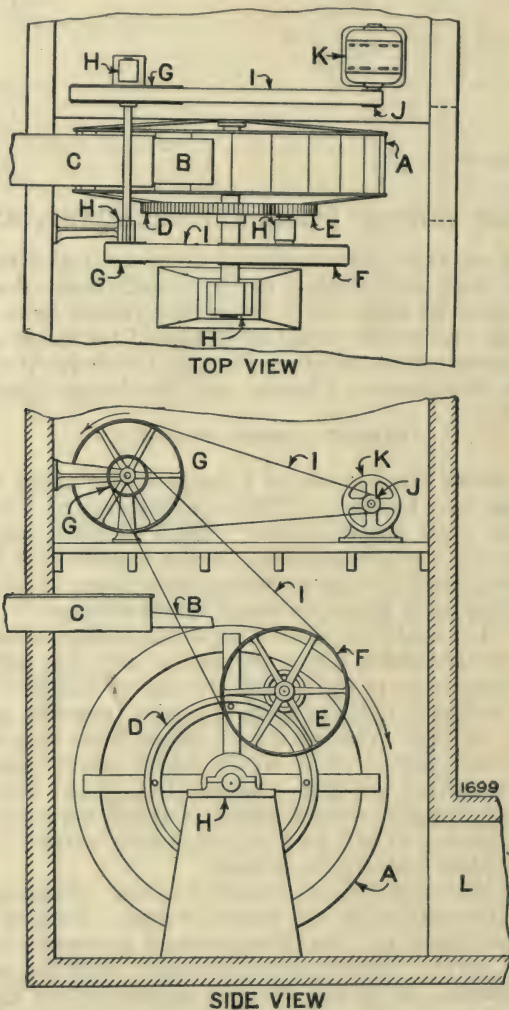


FIG. 27.—Overshot water-wheel installation for driving a high-speed generator. Note the additional pulleys and belt required to step-up the water-wheel shaft speed to that of the generator as compared with Figure 26. A, water wheel; B, chute; C, flume; D, drive gear; E, pinion gear; F, drive pulley; G, intermediate drive pulleys; H, bearing; I, belt; J, generator pulley; K, generator; L, discharge outlet

by houses with current for lighting. This plant would operate under a 7-foot head and 405 cubic feet of water per minute. A small inexpensive diversion dam and earth flume would make possible the development of a $2\frac{1}{2}$ -kw. plant, either by the owner or as a cooperative project, at an estimated cost of about \$750.

Site No. 5.—At this point 405 cubic feet of water under a 9-foot head could be utilized. Although the conditions would permit of the installation of a plant of $3\frac{1}{2}$ -kw. capacity, from which the owner's residence near by and two residences one-half mile distant could be supplied with current, yet, owing to spring floods which would necessitate a substantial dam, it is doubtful whether the present demand

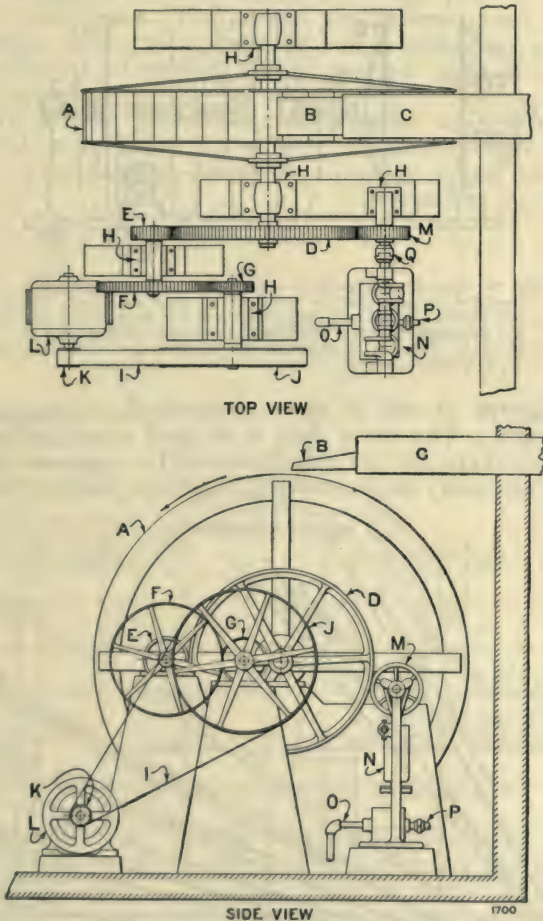


FIG. 28.—Overshot water-wheel installation showing combined water pump and generator drive. A, water wheel; B, chute; C, flume; D, main drive gear; E, main pinion gear; F, generator drive gear; G, generator pinion gear; H, bearing; I, belt; J, generator drive pulley; K, generator pulley; L, generator; M, pump drive pinion; N, triplex water pump; O, pump suction; P, pump discharge; Q, coupling for disconnecting pump

for current would warrant the development. If there were other residences to be supplied, sufficient current might be sold to afford a reasonably good return on the estimated cost of about \$1,600.

Site No. 6.—An abandoned mill site, where the available head is $6\frac{1}{2}$ feet and the volume 405 cubic feet per minute, could be repaired and with a $2\frac{1}{2}$ -kw. plant installed operated to supply two residences

with electric light and possibly some small power devices at an estimated cost of about \$900.

MILL CREEK PROJECTS

Eight power sites were found on this stream in a stretch of $1\frac{1}{2}$ miles. But three of these offered particularly interesting oppor-

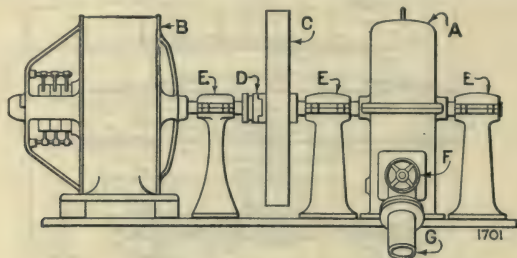


FIG. 29.—Impulse turbine direct connected to generator and pulley mounted on same shaft for belt drive to other machines. The jaw clutch permits easy disconnection of the generator in case the developed power is insufficient to operate all machines at the same time. A, impulse turbine; B, generator; C, pulley; D, coupling; E, bearing; F, control valve; G, supply pipe

tunities. Figures 32 and 33 show, respectively, a general and plan view of one site. The stone dam is in good condition and the old brick mill is in shape for the installation of the necessary machinery. It would be necessary to reconstruct the flume and to purchase and

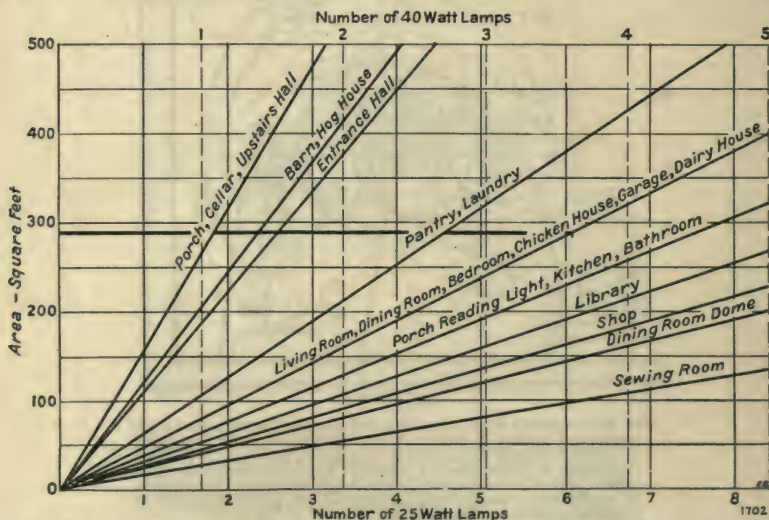


FIG. 30.—Chart for estimating the number and size of electric lamps required for different locations in order to obtain proper illumination and efficient use of current

install the equipment in order to provide the owner with electricity for lighting, cooking during part of the year, a small refrigerating plant, and other uses requiring a small amount of current. The volume of water available, 210 cubic feet of water per minute, under a 12-foot head would operate a plant of $2\frac{1}{2}$ -kw. capacity which might

be developed at an estimated cost of \$710, or about \$284 per kilowatt.

The second site is on the same property a short distance up stream from the first; and could be developed in conjunction with it at a total estimated cost of about \$1,507. The volume of water at this point is 205 cubic feet per minute and the head 13 feet, which, with the power available at the lower site, would provide a combined output of 5 kilowatts. This would enable the owner to operate a cooking range throughout the year and a refrigerating plant of a capacity sufficient to enable him to market fresh meat at retail to near-by towns.

The third site is particularly interesting as it illustrates the possibility of more than one scheme of development. Figure 34 shows how a plant of 5-kilowatts capacity could be developed.



FIG. 31.—Farm power sites on Cripple Creek, Wythe County, Va.

Owing to the steep slope of the land it would be possible, by means of a dam 2 feet high, to obtain 180 cubic feet of water per minute with a 30-foot working head. The water would be conveyed to the plant, comparatively near the owner's residence, through an earth flume.

Sufficient electricity would be available at an estimated cost of \$830, or about \$166 per kilowatt, for lighting, cooking, water-pressure system, sawing wood, and for operating many other machines of medium power requirement. Or, in case the owner did not wish to install so large a plant, or did not care to invest so much money, the power house might be located farther up stream and nearer the owner's residence, as shown in Figure 35. The head would be but 11 feet, a loss of 19 feet, so that the capacity of the plant would be reduced to 2 kilowatts, the estimated cost being \$475.

Another development of this site, but not nearly so economical as the others on this stream, previously described, is suggested in



FIG. 32.—General view of an abandoned mill site on Mill Creek, Montgomery County, Va., which at reasonable cost could be reclaimed and developed as a water-power electric plant. A, transmission line; B, old mill building; C, stone dam; D, owner's residence; E, turbine pit; F, wood trough flume; G, earth flume; H, penstock; I, tailrace

Figure 36. This would provide a plant of 2-kilowatts capacity from a flow of 50 cubic feet of water under a 57-foot head, but the long pipe line would make it expensive. However, the pipe line would

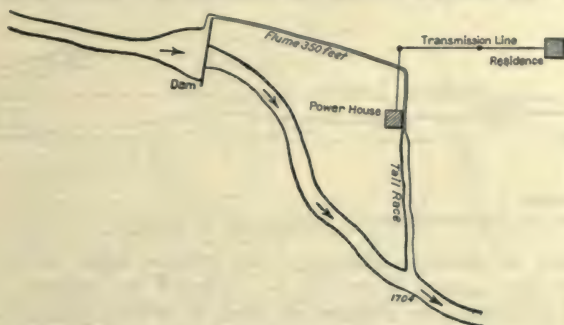


FIG. 33.—Plan view of site shown in Figure 32

conduct water under this high head directly to the owner's house and thus provide for excellent fire protection, which is always desirable.

BUCHANAN CREEK PROJECT

Figures 37 and 38 illustrate an installation on one of the smallest streams the development of which might be considered practicable. During dry periods the stream flow does not exceed 110 gallons per minute. A head of 15 feet can be obtained by building a 2-foot stone



FIG. 34.—Plan for developing, at the uppermost site on Mill Creek, a water-power electric plant of 5 kw. capacity operating on 180 cubic feet of water per minute under a 30-foot head

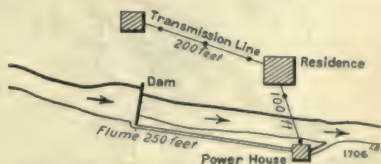


FIG. 35.—Plan for a less costly plant at the same site as shown in Figure 34

dam to form a storage basin between the hills that rise abruptly from the stream bed, and about 150 feet of earth channel for conducting the water to an overshot water wheel, 14 feet in diameter and 1 foot wide. This wheel would drive a 250-watt, 125-volt direct-current generator, from which current would be delivered to a 110-volt storage battery. The estimated cost of the development, including a nickel-iron battery, would be about \$1,300. Ordinarily this project should not be favorably considered, since it involves the construction of a fairly long stone dam, the cost of which is not included in the above estimate. However, since materials are available at the dam site and the labor would be performed by the owner and his sons during spare time, the actual outlay would be such as would warrant the development. The plant would supply electricity to two residences for lighting and small power units. The estimated cost is greater than for the average small water-power plant, due primarily to the small quantity of water available and the distance from the power house to the residence.

SUCCESSFUL HIGH-HEAD PLANT

None of the sites surveyed and described in the foregoing pages offered an opportunity for a high-head plant. Sources of power are

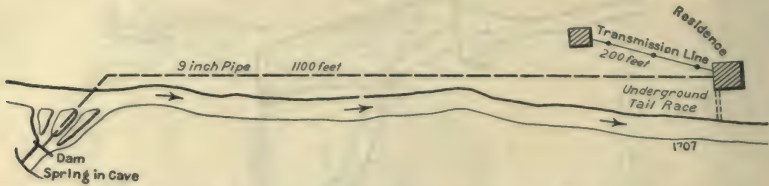


FIG. 36.—Another plan of development for the site shown in Figures 34 and 35

often found in springs issuing from points high up on hillsides. Frequently the spring flow can be utilized to operate an impulse turbine as indicated in Figures 39 and 40 which illustrate an exist-



FIG. 37.—General view of proposed development on Buchanan Creek, Washington County, Va., to supply two residences with electricity. A, transmission line; B, power house; C, stream bed; D, owner's buildings; E, water wheel; F, flume; G, storage basin; H, spring-fed stream; I, neighbor's residence

ing installation of this type. The spring that supplies the water is situated about 1,500 feet from the house and 135 feet above the supply pipe at the wheel. The measurement of the flow from the spring was found to be only 30 gallons per minute.

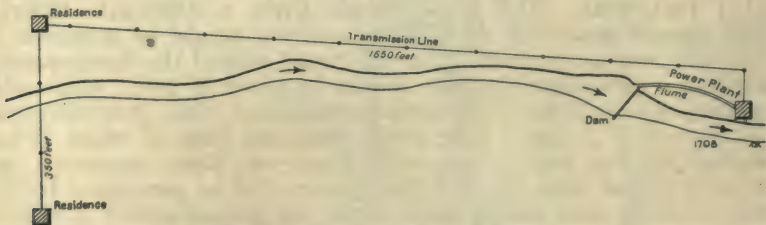


FIG. 38.—Plan view of site shown in Figure 37

A dam as indicated in Figure 40 was built high enough to impound sufficient water to operate the wheel for four hours continuously, this being the time required to charge the battery properly. The

installation consists of a 6-inch impulse water motor operating under a 100-foot working head; a 250-watt d. c. generator and a 16-cell 190-ampere-hour 32-volt lead-storage battery. The plant

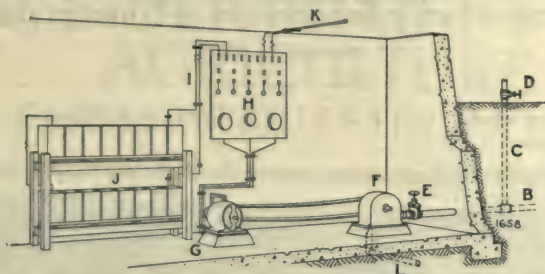


FIG. 39.—Equipment installed for development shown in Figure 40. B, underground supply pipeline; C, branch for fire protection; D, control valve to hose connection; E, control valve to water turbine; F, impulse turbine; G, generator; H, switchboard; I, battery charging line; J, storage battery; K, electric wires to lighting system

supplies the owner with electricity for lighting and small heating units, besides giving him fire protection by means of a valve-controlled outlet in the water pipe line.



FIG. 40.—General view of high-head water power plant. A, dam; B, underground supply pipe line; L, underground tail-water pipe line

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December 30, 1924

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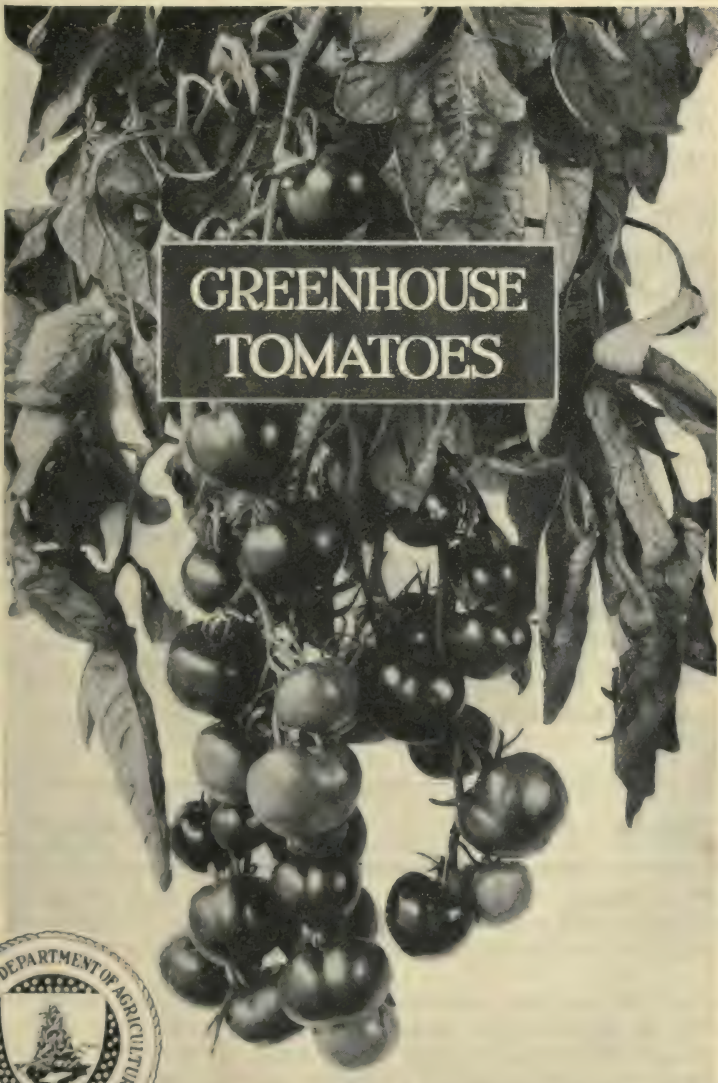
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1431



GREENHOUSE TOMATOES



TOMATOES GROWN IN GREENHOUSES near the markets can be ripened on the plants and put into the consumers' hands within a few hours of the time they are picked.

The quality of greenhouse tomatoes is far superior to that of the outdoor-grown crop competing with it, which is usually picked green and shipped long distances before reaching the markets.

Successful production in greenhouses requires the use of suitable structures with adequate heating and other equipment, good seed of suitable varieties, fertile well-adapted soil, and painstaking care in growing the plants and in handling the crop.

The greenhouse operator who can provide the high-grade equipment necessary and give the crop the care it demands is likely to find an increasing market for his product.

GREENHOUSE TOMATOES

By JAMES H. BEATTIE, *Associate Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry*

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INTRODUCTION

THE COMMERCIAL PRODUCTION of tomatoes in greenhouses in the United States is a development of the past quarter of a century. Previous to about 1900 little attention was paid to the forcing of the crop in glasshouses, the present importance of which is a marked tribute to the excellence of the product and the success of vegetable-greenhouse men in working out methods for handling this, the most difficult of the important vegetable forcing crops. Lettuce, cucumbers, and tomatoes constitute perhaps 90 per cent of the products of the vegetable-forcing ranges throughout the United States. Some ranges devote their energies to lettuce and cucumbers, but most of them grow tomatoes at some time during the year.

According to the 1919 census, the value of the vegetable crops grown in greenhouses aggregated \$15,487,878, almost every State in the Union being represented as a producer. Nearly \$14,000,000 worth of the products came from the New England, Middle Atlantic, East North-Central, and West North-Central States. Climatic conditions largely account for the absence of the industry in the South Atlantic, Gulf Coast, and Southwestern States, where it is usually possible to produce a long list of fresh vegetables as outdoor crops over the greater part of the year, and these sections also are accessible to tropical centers where year-round production of certain vegetables is possible.

Greenhouse ranges devoted to the tomato crop are to be found throughout the States where the industry has attained its greatest importance. Arlington, Mass., and Grand Rapids, Mich., are the two oldest important forcing centers. Large greenhouse ranges are to be found around Rochester, N. Y.; Philadelphia, Pa.; Ashtabula,

Cleveland, Toledo, and Columbus, Ohio; Chicago, Ill.; and other points. Suitable soil, ample labor, cheap fuel, and good transportation facilities have been contributing factors in the development of the industry in many sections.

When ripened on the vine, greenhouse tomatoes are far superior in quality to those grown outdoors in warm sections, where it is necessary to pick the fruit green in order to get it into the hands of the distant consumer without undue loss. Tomatoes marketed during the winter and early-spring months when prices are high are usually served as a salad or as an ingredient of a salad. A comparatively small quantity is ample for several persons; hence the vegetable is as economical to the housewife as other available salad crops.

The greenhouse owner must make a large investment in houses and equipment, and he must be prepared to spend large sums for the maintenance of conditions suitable for this exacting crop. On the



FIG. 1.—A large greenhouse devoted to a crop of tomatoes. The plants are trained to slender stakes set in the ground near them and supported by wires attached to the frame of the structure

other hand, a grower 2,000 or more miles from the markets must spend large sums for picking, packing, transportation, and handling before his crop can be realized upon. The products of properly located greenhouse ranges where fuel, labor, and other essentials can be obtained economically are usually able to compete successfully with tomatoes grown at distant points out of doors. The vegetable-forcing industry is increasing in importance, and the tomato is receiving its full share of attention.

GREENHOUSES

A forcing house for tomatoes must be suitable for the exacting requirements of the crop. It must be of such construction that the least possible interference is offered to the entrance of light. It must be fitted with a ventilating system that permits the changing of the air without drafts, and it must have a heating system capable

of maintaining a sufficiently high and uniform temperature. A house containing a large volume of air is usually less subject to sudden fluctuations in temperature than a small house. Moreover, a high house with the ventilators several feet above the plants usually makes it possible to ventilate without drafts striking the plants. The house must have sufficient headroom for the plants, but structures meeting the other important requirements usually have an abundance of such room for tomatoes.

Detached houses 60 to 80 feet wide and 500 to 600 feet long (fig. 1) are largely used. The ridge-and-furrow type, with high gutters, is widely used for tomatoes. These houses are built in widths up to about 40 feet without inside posts, a steel truss supporting the roof in the wider ones. Three of these houses may be made to inclose a space 100 or more feet in width having only two outside walls, two inside gutters, and two rows of inside posts, each row being



FIG. 2.—Greenhouse tomatoes on raised benches. The plants are trimmed to a single stem and trained to strings tied to the roof of the greenhouse

directly beneath and supporting a gutter. The inside gutters cast some shade on the crop, but if they are sufficiently high this objection is negligible. The present tendency is toward large houses with high side walls of sash-bar and glass construction and with roofs so high that the glass is at a considerable distance from the plants. Whether the house is a large detached pipe-frame or steel-frame structure or consists of a number of ridge-and-furrow houses with high side walls so constructed that there is the least possible interference with the admission of light seems to be immaterial so long as the structure fulfills the requirements of this very particular crop.

BENCHES COMPARED WITH GROUND BEDS

During the early days of the industry practically all tomato growers believed that raised benches and bottom heat were essential to success with the crop (fig. 2). It was soon found that good crops

of tomatoes could be produced in houses without raised benches where the space was treated as an inclosed area to be handled in much the same manner as intensively conducted outdoor operations. Benches are still used to a limited extent in tomato houses, but in houses of newer construction there is a growing tendency to dispense with them.

Many growers believe that tomatoes grown on benches require several days less time to come into bearing than those planted in ground beds. Bottom heat from pipes located under the benches, better aeration of the soil on the benches, and better drainage all contribute to the earliness of the bench crop. Provision for adequate drainage, care in watering, and the use of temporary heating lines laid on the surface of the soil during the early stages of growth make it possible to secure earliness equal to that of the crop planted in ground beds. Benches are very expensive, and the cost of maintenance is often high. They bring the plants near the glass,



FIG. 3.—Tomatoes growing in a house where the plants are set and handled in much the same manner as where the crop is grown intensively outdoors. The concrete curbs are used to keep the soil out of the cinder walks

where they are more subject to fluctuations in temperature and more difficult to cultivate, trim, and train. Moreover, the tomatoes are difficult to gather when grown on raised benches. Under present methods of culture the natural ground beds are often plowed with a team or tractor, and the cost of applying the manure and preparing the soil is much less than when the work is done by hand on raised benches. The thin layer of soil usually employed on raised benches must, as a rule, be changed every year, but with ground benches such a procedure can usually be avoided. The ideal tomato house is a small field under glass where temperature, moisture, and other suitable growing conditions can be maintained (fig. 3).

WALKS

Concrete walks are considered an essential part of the modern vegetable house, since they serve as tracks for wheelbarrows or trucks used in handling the crop. However, the space occupied by walks

is involved in heat and maintenance costs, and therefore only absolutely necessary walks should be installed. Figure 1 shows the interior of a large house with concrete walks along each side. This is an excellent arrangement, as it is impossible to grow tomatoes near the heating pipes, where they would be subjected to excessive heat and also to drafts from the side ventilators. The house shown has but two permanent walks, with temporary board runways between the rows of plants. Interior walks are sometimes placed in line with interior rows of posts, but these interfere with the use of the walks for trucks, wheelbarrows, etc. In ridge-and-furrow houses narrow walks are nearly always placed under the gutters and around the posts. Although they do not serve as tracks for conveyances used in handling the crop, they occupy space not well suited to the crops and leave the remaining area in the house unobstructed. An occasional crosswalk is sufficient for crop-handling purposes.

HEATING

The heating system employed must be capable of maintaining a uniform temperature, as sudden fluctuations are very injurious to the crop. A gradual change from about 60° F. at night to 70° or 85° F. during the day is permissible, but hourly fluctuation either day or night will usually prove harmful to the crop. The hot-water system, using either forced or gravity circulation, and vacuum and low-pressure steam systems give good results. Gravity-circulation hot-water systems are well suited to houses of moderate size. The rate of circulation is slow, necessitating the use of more radiation than is needed with certain forced-circulation or steam systems. Moreover, this type of system is not particularly adapted for use in very large houses. In small plants, where the care that can be given the boiler is usually limited, hot water is especially suitable, as the large volume of water in the system cools slowly, making frequent attention unnecessary. Forced-circulation hot-water systems are in satisfactory use in many plants. A pump of suitable type is used to hasten circulation, and in some cases the system is so arranged that entire dependence is placed on the pump for circulating the water. Vacuum and low-pressure systems require less radiation than is necessary for hot-water systems. They are very satisfactory, being particularly adapted to large houses and to ranges where the boilers have regular attention.

The size and arrangement of the piping in a tomato greenhouse are determined by the kind of heating system employed and by the size and construction of the house. Although overhead piping casts some shade on the developing crop, it is generally believed that at least a part of the radiation should be overhead, as pipes so located temper the air entering through the top ventilators and prevent cold drafts from striking the plants (see fig. 1). For the same reason it is desirable that part of the radiation be placed on the side walls. The current of warm air rising from pipes so placed prevents cold air entering through the walls and roof from striking the plants. The crop is safely blanketed under a canopy of warm air through which cold drafts are not liable to penetrate. The gable ends of large houses are usually supplied with banks of pipe to cut off the cold air from these large exposed surfaces.

Hot-water or steam heating systems can readily be adapted to such an arrangement of the pipes. The flow pipes are usually placed overhead at a higher level than the coils, with the whole system graded so that it slopes gradually downward to the boiler. With narrow ridge-and-furrow houses the radiating pipes are usually placed on the posts supporting the gutters, but in wider houses of this type at least a part of the radiation is placed overhead.

Table 1 shows the radiation needed to maintain temperatures suitable for tomatoes.

TABLE 1.—*Temperatures to be maintained and length of pipe of different sizes needed to supply radiation for gravity-circulation hot-water systems*

[Steam-heating systems take three-fifths of the length of pipe here stated]

Temperatures to be maintained	Radiation for each 1,000 square feet of glass or its equivalent ¹ (square feet)	Length of pipe required to supply this radiation (feet)		
		1½-inch size	1½-inch size	2-inch size
60° to 65° F.....	401	920	801	641
65° to 70° F.....	460	1,057	921	737
70° to 75° F.....	583	1,339	1,166	933

¹ By the term "equivalent" is meant the side walls of wood or masonry construction; 4 square feet of exposed surface of this character is figured as needing the same radiation as 1 square foot of exposed glass surface.

The exact amount of radiation to be installed can be determined only after giving consideration to such factors as geographical location, tightness of houses, exposure, and efficiency of the heating plant. In sections where low temperatures prevail or occur at intervals it is necessary to install more radiation than that shown in the table. The figures given are for an outside temperature of 0° F. Where lower temperatures occur the amount of radiation should be increased at least 1 per cent for each degree below zero. Thus, in sections where the temperature occasionally falls to -20° F., 20 per cent more radiation should be installed. Greenhouses in very exposed positions should have additional radiation, especially on the side from which the prevailing winds come.

VENTILATORS

Greenhouses for tomato growing usually have ventilators along the side just below the eaves and along both sides of the ridge. Side ventilators are often hinged just below the eaves and operated by machines attached to the side posts of the structure. Top ventilators are generally hinged to a member just under the ridge cap. Unless opened very wide such an arrangement allows water to drop from the ventilators to the roof. The overhanging ridge cap makes a water-tight joint. Machines for operating the top ventilators are placed on posts or pedestals at suitable intervals and within easy reach of the operator. Extreme care in securing tight-fitting easy-operating ventilators prevents drafts and aids materially in obtaining good crops.

WATER SYSTEMS

Water pipes are usually placed under the beds and fitted with enough faucets so that any part of the house can be reached with 50 to 75 feet of hose. When the application of water is to be made entirely with a hose no additional equipment is necessary.

Subirrigation systems composed of lines of tile spaced from 2 to 4 feet apart and buried in the soil sufficiently to be out of the way of tillage tools make it possible to water the crop without packing the surface or wetting the foliage. The size of the tile, the distance between the rows, and the depth the tile is buried are determined largely by the character of the soil. Very tenacious or impervious soils, where the lateral movement of the water is slow, require the installation of lines of tile nearer together than is necessary with lighter soils. The lines of tile are provided with openings every 100 to 150 feet, so that the end of a hose can be inserted; and the water is run into the tiles until they are filled or the soil sufficiently moistened, when the hose is moved to the next line. This system insures against overwatering, as the lines of tile serve as drains also, and much benefit is secured by the aeration of the soil. Greenhouse-vegetable growers could well devote more attention to the subirrigation method of applying water.

Overhead sprinkler systems are extensively employed during the early stages of the crop, or until about the time that the blossoms appear; but they have not met with much favor for growing tomatoes, because wetting the foliage creates greenhouse conditions favorable to the development of certain diseases and unfavorable for the ripening and transfer of pollen.

CROPPING PLANS

Tomatoes are seldom grown as a midwinter greenhouse crop. They are usually produced during the fall and early winter or as a spring crop. Few vegetable growers produce tomatoes alone, experience having proved that it is better practice to follow a definite greenhouse rotation, including two or more of the important forcing crops. No definite cropping plan suited to the needs of growers located in the various sections can be given. The rotations here suggested are followed very closely by many growers in the important forcing sections of New York, Pennsylvania, Ohio, Michigan, and elsewhere.

Plan 1

Tomatoes.—Seed sown July 1 to 15. Plants set in houses August 15 to 30. Vines removed December 15 to 30.

Lettuce.—Seed sown November 15 to 30. Plants set in houses December 15 to 31. Crop harvested March 15 to 31.

Cucumbers.—Seed sown February 1 to 15. Plants set in houses April 1 to 15. Vines removed July 1 to 15.

Plan 2

Tomatoes.—Seed sown July 1 to 15. Plants set in houses August 15 to 30. Vines removed December 15 to 30.

Lettuce.—Seed sown November 15 to 30. Plants set in houses December 15 to 31. Crop harvested March 15 to 31.

Lettuce.—Seed sown February 1 to 28. Plants set in houses March 15 to 31. Crop harvested June 1 to 15.

Plan 3

Lettuce.—Seed sown August 1 to 15. Plants set in houses September 1 to 15. Crop harvested November 15 to 30.

Lettuce.—Seed sown October 15 to 30. Plants set in houses November 15 to 30. Crop harvested February 1 to 28.

Tomatoes.—Seed sown January 1 to 15. Plants set in houses March 1 to 15. Vines removed to make room for following crops when no longer productive.

Plan 3 is sometimes modified by growing fall tomatoes instead of the first crop of lettuce. The dates given are approximate, as crops are usually set over a period of two or three weeks, and the date of harvesting is determined to a certain extent by weather and other conditions. The greenhouse operator is anxious to have a steady supply for his markets and plans the setting of his crops to give him such a supply.

Fall-grown tomatoes do not as a rule yield such heavy crops as those ripening during early spring, when weather conditions are much more favorable.

Greenhouse tomatoes, during the early stages of their growth, do not fully occupy the space in which they are planted. (See fig. 1.) Some growers plant quick-maturing crops, such as radishes, beets for greens, and lettuce, between the tomato rows, removing these before the tomatoes require the space. Conditions are maintained according to the needs of the tomatoes; and although not ideal for cool crops like radishes and lettuce returns are often sufficient to cover the expense of bringing the tomatoes well toward the producing stage. Each grower should determine for himself which, if any, crop should be used as a catch crop with tomatoes; sometimes it may prove best to dispense with catch crops altogether.

SOILS

Tomatoes are grown on a wide range of soil types. They are successfully produced upon soils varying from heavy clays to light sands. Light soils are easier to work and ordinarily bring the crop into bearing somewhat sooner than do heavier soils. When the crop is grown on benches where soil only a few inches deep is used, it is usually changed each year. This practice permits the choice of a soil of loamy character made, if possible, of sods from an old pasture the soil of which is a rather light clay loam or a heavy sandy loam. With this should be mixed about one-fourth of its bulk of well-rotted stable manure, preferably cow manure. By composting these two materials several months before they are required for use, a very satisfactory soil for the forcing of tomatoes is produced.

An excellent soil may be prepared by composting fresh sod soil from an old pasture with one-fourth to one-third its volume of organic or muck soil. To be suitable for this use, the muck must be from a deposit that has been reclaimed and devoted for a few years to the growing of cultivated crops, such as corn, flax, hay, onions, and cabbage. It must contain at least 80 per cent of organic matter, and must not be acid, or contain over 40 per cent of moisture. It must, moreover, be high in plant food, containing at least 2.5 per cent of nitrogen and 0.5 per cent of both phosphoric acid and potash. Such humus can be obtained in many localities, but the

advisability of using it must be determined by its cost. If manure is abundant and cheap there would be little to gain in using the muck.

If the supply of manure is limited, soil, muck, and manure may be used together with excellent results. A compost made of 4 parts of old-pasture sod, 1 part of rotted cow manure, and 1 part of suitable muck will generally give excellent results and should be prepared in the manner usually followed. The mixture of the manure and muck often gives better results than is obtained from the use of the materials separately.

Manure, muck, or any of the composts just mentioned may be used in houses where the soil is not changed and where it is desirable to lighten heavy soils, add organic matter and plant food, or otherwise make the soil more suitable for the production of maximum yields of greenhouse crops. When following such rotations as those suggested on page 7, the application of the organic matter and much of the plant food takes place before planting the other crops included in the rotation, as tomatoes do not require the heavy fertilization essential to both lettuce and cucumbers.

SOIL PREPARATION

Although greenhouse conditions necessitate the following of methods in the preparation of the soil somewhat different from those commonly followed outdoors, the principles are the same. With the large forcing houses now in use it is often possible to employ teams or tractors for the plowing, disking, rolling, and other operations in the well-prepared soil necessary to successful greenhouse-tomato growing. In smaller houses without benches and in those fitted with raised benches handwork is depended upon. The preparation of greenhouse soils is fully discussed in *Farmers' Bulletins* Nos. 1320, "The Production of Cucumbers in Greenhouses," and 1418, "Lettuce Growing in Greenhouses."

PLANT FOOD

Soils well supplied with organic matter and plant food from such composts as those described on page 8 should require but little additional fertilization for the production of a good crop of greenhouse tomatoes; in fact, when tomatoes follow lettuce and cucumbers which have been heavily manured there is great danger that additional applications of manure may result in excessive vine growth at the expense of the fruit. When planting the various crops according to a plan whereby the tomatoes follow other crops, as in the case of the rotation suggested on page 8, it may be necessary to use more compost, manure, or commercial fertilizer on the tomatoes.

COMMERCIAL FERTILIZERS

Material containing a high percentage of nitrogen must be used with great caution, as an excess of nitrogen causes excessive vine growth and dropping of the blooms, with failure to bear satisfactory crops. With plentiful supplies of good manure or good compost but little additional nitrogen is needed as a rule. Phosphoric acid is very necessary to the tomato and may be used in liberal quan-

tities with profitable results. Either bone meal or acid phosphate is generally employed. Potash also is essential to the growth of greenhouse tomatoes and may be applied in the form of hardwood ashes, muriate of potash, or some other form of the element. It is difficult to make definite recommendations as to the quantity of commercial fertilizer that should be applied, as this depends largely upon the past treatment of the soil. When using fresh compost little additional fertilization should be necessary or desirable. With soils which have been heavily cropped, applications of a mixture containing 1 to 2 per cent of nitrogen, 8 per cent of phosphoric acid, and 4 to 6 per cent of potash at the rate of from 10 to 20 pounds to each 1,000 square feet of surface should be sufficient. The grower must be guided by his own conditions in using commercial fertilizer, and, if his greenhouse-tomato crop indicates the need for such plant food, it should be applied.

MANURE

The use of manure as an ingredient of the soil has already been discussed. Additional use is often made with profitable results by employing it as a mulch, and when obtainable at reasonable cost this use is to be recommended. Fine strawy manure is preferable for this purpose, as such material protects the soil from rapid drying and keeps it mellow. The plant food in the manure is made available to the plants by leaching. Well-decomposed peat and muck of suitable character can also be used to good advantage for the maintenance of a mulch around the plants.

LIME

Where needed to correct soil acidity or as an aid in improving the physical character of the soil, lime should be used before attempting to grow a crop of greenhouse tomatoes. Heavier soils are more likely to need lime, but in all cases an actual test is necessary. Generally applications of 30 to 50 pounds of ground hydrated lime per 1,000 square feet of ground will be sufficient.

VARIETIES AND SEED

The tomato has long been popular as a glasshouse crop in England, where a large number of special small-fruited forcing varieties have been developed. These so-called English varieties are largely grown in greenhouses in the United States, particularly in the eastern section of the country. Carters Sunrise, Stirling Castle, Comet, Duke of York, and Perfection are kinds extensively grown. All of these are characterized by a large number of tomatoes borne in each cluster. The title-page illustration shows a portion of a plant of Carters Sunrise, a sort having particular merit. American varieties of tomatoes are extensively used for forcing work, especially in the Middle West. Globe, Bonny Best, and Stone are varieties largely grown. The market demand influences the choice of type and variety for forcing work, as some sections prefer the smaller English type and other regions demand the larger American type. Work carried on at the Arlington Experiment Farm showed no

great difference in the yielding qualities of the English and the American tomatoes. Table 2 gives results obtained with several of these.

TABLE 2.—Comparative yields of different varieties of tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va., August 17, 1917, to January 31, 1918

Variety	Number of plants	Weight of tomatoes (pounds)		Variety	Number of plants	Weight of tomatoes (pounds)	
		Total	Per plant			Total	Per plant
Earliana.....	30	150.53	5.02	Carters Perfection.....	30	80.69	2.69
Burbank.....	30	141.82	4.72	Carters Comet.....	30	79.28	2.64
Bonny Best.....	30	86.92	2.90	Listers Perfection.....	30	60.21	2.01
Globe.....	30	80.94	2.70	Tresco.....	30	103.96	3.46
Ponderosa.....	30	115.47	3.85	Carters Duke of York.....	30	68.92	2.30
Carters Sunrise.....	30	106.25	3.54	Livingstons Comet.....	30	64.91	2.16

In this test the American large-fruited varieties gave a greater total yield and a larger yield per plant than most of the English varieties. Both Earliana and Burbank bore heavy crops of large irregular tomatoes. Of the American varieties the Bonny Best and Globe gave moderate yields of high-class tomatoes. In the autumn and winter of 1918 a similar test was conducted. The results of this are shown in Table 3.

TABLE 3.—Comparative yields of different varieties of tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va., August 25, 1918, to January 7, 1919

Variety	Number of plants	Weight of tomatoes			
		Total		Per plant	
		Pounds	Ounces	Pounds	Ounces
Globe.....	31	130	9	4	3½
Dwarf Champion.....	32	116	11	3	10½
Tresco.....	32	182	2	5	11
Stirling Castle.....	29	174	4	6	0
Listers Perfection.....	20	163	14	5	10½
Carters Comet.....	32	145	13	4	9
Duke of York.....	29	137	13	4	12
Comet (B).....	32	131	4	4	1½
Carters Sunrise.....	24	127	13	5	5
Carters Perfection.....	32	119	5	3	11½

The yields, especially those from some of the English varieties, were very good for a fall crop, lower yields being usually obtained from fall-grown greenhouse tomatoes than from the spring crop.

Seed of two varieties, Carters Sunrise and Stirling Castle, saved from selected plants grown in the greenhouse at the Arlington Experiment Farm, was used in 1920 for the production of a spring crop in the same house used for the previous work. The results of this test are given in Table 4.

TABLE 4.—*Comparative yields of two varieties of English forcing tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va.*

[Seed sown February 9; set in house March 25; first ripe tomatoes June 23; last, August 13, 1920]

Variety	Number of plants	Weight of tomatoes			
		Total		Per plant	
		Pounds	Ounces	Pounds	Ounces
Carters Sunrise.....	47	450	7	9	9
Stirling Castle.....	46	419	7	9	1

The data in these tables are presented to show what occurred under the conditions found in the houses where this work was conducted. Globe and Bonny Best seemed to be the best all-round large varieties tested. Carters Sunrise, Stirling Castle, and Comet were apparently the best of the English forcing sorts. Many growers of greenhouse tomatoes maintain their own seed stocks, and in some cases these are as distinctive as the named commercial varieties. The greenhouse tomato readily lends itself to improvement by selection and crossing, and some growers pay considerable attention to building up and maintaining strains suited to their needs. The Irondequoit (N. Y.) greenhouse men have a select strain of an English forcing tomato which is maintained from year to year, the seed of which may be grown in the greenhouse or in the open. A large number of plants can be produced from a small quantity of seed, and the use of good seed of a variety and strain suited to the purpose to which it is to be devoted is recommended.

STARTING AND GROWING PLANTS

Tomato growers usually grow their own plants. The practice gives them the assurance of a supply of stocky, vigorous plants of the variety and strain desired and makes it possible to set the plants in the houses without the risk of shock and injury incident to shipping. By growing and handling his own plants the grower is able to reduce the danger of introducing diseases, such as *Fusarium* wilt,¹ and nematodes.²

QUANTITY OF SEED AND NUMBER OF PLANTS REQUIRED

There are over 8,000 tomato seeds to the ounce, and a very small quantity of good seed is required to start plants for a large area. It is always best to use sufficient seed to give an abundance of seedlings. In practice, seed of high vitality should give 2,000 to 3,000 first-class plants per ounce. It is a wise insurance to provide twice the number of plants needed to set the space to be devoted to the crop. Table 5 shows the actual number of plants needed to plant each 1,000 square feet of bed when spaced at varying distances.

¹ The wilt is due to the attacks at all stages of the development of the plant of *Fusarium lycopersici* Sacc.

² The gall-like swellings on the roots are caused by the attacks of an eelworm, *Heterodera radiculicola* (Greef) Müller.

TABLE 5.—Tomato plants required to set each 1,000 square feet of bed when spaced at varying distances

Distance between rows	Distance between plants in the row	Plants for each 1,000 square feet of bed space ¹	Distance between rows	Distance between plants in the row	Plants for each 1,000 square feet of bed space ¹
	<i>Ft. In.</i>	<i>Number</i>		<i>Ft. In.</i>	<i>Number</i>
2 feet.....	2 0	250	3 feet 9 inches.....	1 6	178
2 feet 6 inches.....	2 0	200	3 feet 9 inches.....	1 9	153
2 feet 9 inches.....	1 6	242	3 feet 9 inches.....	2 0	133
3 feet.....	1 3	267	4 feet.....	1 0	250
3 feet.....	1 6	222	4 feet.....	1 3	200
3 feet.....	1 9	190	4 feet.....	1 6	167
3 feet.....	2 0	167	4 feet.....	1 9	143
3 feet 3 inches.....	1 3	246	4 feet.....	2 0	125
3 feet 3 inches.....	1 6	205	4 feet 3 inches.....	1 0	235
3 feet 3 inches.....	1 9	176	4 feet 3 inches.....	1 3	188
3 feet 3 inches.....	2 0	154	4 feet 3 inches.....	1 6	157
3 feet 6 inches.....	1 3	229	4 feet 3 inches.....	1 9	134
3 feet 6 inches.....	1 6	190	4 feet 6 inches.....	1 0	222
3 feet 6 inches.....	1 9	163	4 feet 6 inches.....	1 3	178
3 feet 6 inches.....	2 0	143	4 feet 6 inches.....	1 6	148
3 feet 9 inches.....	1 3	213			

¹ The outside rows of plants are figured as occupying the edge of the area. Adjacent areas of equal size would require slightly fewer plants.

In producing tomato plants the methods followed are determined to a great extent by the season of the year during which the crop is to be grown. Plants for the fall crop are often produced outdoors in a place where they can receive the necessary attention. Cold-frames or hotbeds without heat are often used. The greenhouse is usually too hot during July and August for the production of good plants. For the spring crop most growers utilize a separate house where the tomato plants can be well protected and given the best of care.

SOIL FOR TOMATO SEEDLINGS

A soil of a friable character well supplied with organic matter is especially adapted to the production of tomato plants. When loam soils of the proper character are not available for the preparation of composts for the starting and growing of the plants, satisfactory results may be secured with other types provided they are modified through the use of muck, manure, sand, or in the case of light sands heavier soils to bring them to the proper physical, moisture-retaining, and plant-food-bearing condition. A compost made of 3 to 4 parts of bluegrass sod and 1 part of cattle manure is excellent. Such a compost should be prepared several months in advance of the time it will be needed and turned two or three times to insure a perfect mixture. It should be sufficiently decayed so that practically all the grass roots and vegetable matter in the manure have disappeared. At the final turning it should be screened to remove stones, lumps, or fibrous matter, and it is an excellent plan to add 2 to 4 pounds of ground bone to each ton of the compost.

Owing to the general prevalence of such diseases as Rhizoctonia and other damping-off fungi, which are liable to attack the seedlings, it is usually best to sterilize the soil. Sterilization can be effected by spreading the soil 6 or 8 inches deep on a concrete floor and

wetting it with a solution of formaldehyde, 1 part of the chemical to 99 parts of water, using a gallon of the mixture to each square foot of soil. Sterilization by steam can be effected by spreading the soil in the greenhouse or on a floor and using the inverted steam pan, as described in Farmers' Bulletin 1320, *The Production of Cucumbers in Greenhouses*. Another method consists in placing the soil in the flats to be used for growing the seedlings and putting these in a wooden or concrete cabinet fitted with pipes for the admission of live steam. The steam is turned on and the soil heated to about 212° F., this being accomplished as a rule in 30 to 45 minutes. The flats must be allowed to stand until sufficiently dry to permit handling the soil before the sowing is done.

The seed is usually sown in drills 2 to 3 inches apart. A convenient method for making the rows consists in pressing the edge of a plastering lath into the well-fined seed bed to a depth of half an inch, repeating the operation for adjoining rows. The seed should be uniformly distributed in these drills at the rate of about four to each inch and covered by filling the furrows with loose loam, leaf mold, muck, or a mixture of sand and soil. Whatever material is used it should be of a friable character, so that the seedlings can come through the surface without difficulty. It is desirable that the soil be kept in an ideal moisture condition. If too wet the seed may rot, and if too dry it will not germinate satisfactorily. It is often advisable to cover the bed with burlap until the seeds germinate, but when this is done care must be exercised to remove the burlap by the time the seedlings begin to come up. Temperatures ranging from 70° to 75° F. are satisfactory for the germination of tomato seed. After the seedlings are well up this may be reduced somewhat. Moderately low temperatures are favorable to the securing of stocky plants.

Tomato plants for the greenhouse crop are usually transplanted. The seedlings are ready for transplanting in from 10 days to 2 weeks after the seed is sown. They are sometimes moved to flats, where they are set from 2½ to 3½ inches apart and left there until moved into the house where the crop is to be grown. In other cases they are transplanted to paper pots or thumb pots and later shifted to larger pots, plant bands, or berry baskets. The farther the plants can be carried in the plant house without stunting them or allowing them to become rootbound or overcrowded and spindling, the less time will be required for securing the crop in the greenhouse. From 4 to 8 weeks are usually allowed for the production of the plants.

Outdoor-grown plants for the fall crop must be produced under prevailing temperature conditions. Excessively high temperatures can be partly overcome by shading the plant bed. Greenhouse-grown plants for the winter or spring crop are usually grown in a special house or in a part of one of the main houses. After the plants are up, a day temperature of 60° to 70° F. with a night temperature some 5 to 10 degrees lower is usually satisfactory. Good strong plants are essential to securing profitable yields of high quality.

ESTABLISHING THE CROP IN GREENHOUSES

Plants for the fall crop are usually set during August or early in September. Many of the larger growers in the northern Ohio district aim to plant about August 15; and it is seldom desirable to defer fall planting much after September 1, as by so doing the crop comes into bearing during the shortest days of the year, when a minimum amount of light is available. March 1 is a favorite date for setting the plants for the spring crop, but the time varies to suit conditions. It is not desirable to set the plants until the coldest weather is over, as large quantities of fuel would be required to maintain the interior of the houses at a temperature suitable for satisfactory growth. Neither is it desirable to defer planting until the product would mature at a time when low-priced outdoor-grown tomatoes are available on the markets. Plants set about March 1 usually begin to produce ripe tomatoes late in May or early in June. Soil, temperature, weather, variety, cultivation, and many other factors affect the time of ripening.

PLANTING DISTANCES

The width of the beds, type of house, and system of training to be followed must be taken into account in determining the planting distances. There is little to be gained by too close spacing, as this results in excessive shading and lowered yields per plant. Most of the large growers set the plants in rows 3 to 4½ feet apart with the plants from 12 to 18 inches apart in the rows, although all the planting distances given in Table 5 are used. Varieties having a small habit of growth may be placed closer together than those inclined to make a heavy growth.

SETTING THE PLANTS

The soil should be given a final surface working just before the plants are set. The beds are usually laid off with a marker or with a garden line. Furrows about 6 inches deep are often made with a light tractor or with a horse-drawn plow. When the plants are being set such distances as would make possible the practice of cultivation in both directions it is very necessary that they be accurately "checked," so that the rows will be straight. This is usually done by using cross lines or in large houses by marking the ground in both directions.

Planting follows the usual practices adapted to this class of plants. Those grown in flats are cut apart, leaving as large a ball of soil and roots as possible on each plant, and set in position with the earth firmly packed about them. Plants grown in paper or wooden bands, berry boxes, or other containers are handled in much the same way. It is desirable that the band or berry box be removed when setting the plants, but with such care as to leave the root system intact. The freshly set plants are always watered, and if planted at a season when the sun is hot they should be moderately shaded for a few days.

CULTIVATION

When proper preparation of the soil has been made, cultivation is limited to maintaining a surface mulch and the resultant control of weeds. Deep cultivation is undesirable and likely to be injurious to the root system of the plants. Hand tools, such as the hoe, scuffle hoe, and rake, are employed. Horse-drawn tools are not largely

used for the cultivation of greenhouse tomatoes. Some growers mulch the ground between the plants, using fine strawy manure, and give no cultivation after the mulch is applied.

TRIMMING
AND TRAINING

The single-stem system of trimming and training is almost universally followed, although some growers train the vines to two and sometimes three stems. As the plants grow, the shoots arising between the leaves and the main stem are removed, so that the energy of the plant is thrown into the main stem. Trimming is usually continued until the plant reaches the top of its support as a single stem, after which it is limited to the removal of shoots appearing on the



FIG. 4.—Tomato plants trained to strings

main stalk and in the top of the plant, which usually tend to droop downward. Unless the plants are kept well pruned the foliage will interfere with the admission of sunlight and the development of ripe tomatoes. Some growers make a practice of removing about half of each leaf borne on the lower part of the plant, in order that the light will have better access to the plants.

Great caution must be exercised in trimming to avoid spreading such diseases as bacterial wilt³ and mosaic, both of which may be readily transmitted from plant to plant by the pruning knife or by the hands. Plants showing symptoms of these diseases should be

³ Caused by *Bacillus solanaceum* Erw. F. Smith.

passed by and trimmed later, when special precautions should be taken to prevent the further spread of the diseases. One of the most effective methods of preventing their spread is to sterilize the pruning knife and the hands in a 1 to 500 solution of corrosive sublimate after handling each suspected plant.

One method of supporting the plant consists in running a heavy twine from a small stake driven into the ground near the base of the plant or a coil-wire anchor twisted into the soil in the same location to an overhead attachment, such as a wire or rod secured to the frame of the greenhouse (fig. 4). The plant and the string are

gently twisted together as growth proceeds, and an occasional tying of the main stem of

the plant to the string with soft twine or raffia is sufficient to give proper support. Figure 5 shows the

interior of a house planted to tomatoes trained to a single stem and supported by stakes. These

stakes or laths, about half an inch thick and an inch wide, are set in the

ground near the plant and tied to overhead wires or other supports, and they are extensively used.

The plants are usually trimmed to a single stem, and tied every few inches to the

stakes with a very soft twine or raffia. The best practice is to tie the string or raffia loosely around the plant just below a fruit cluster or a leaf and tightly to the stake. This method of

tying the plants allows the stems to increase in size without being cut by the string, yet supports them when the weight of the tomatoes tends to pull them down (fig. 6). Still another method of training is illustrated in Figure 3. Horizontal wires borne by posts or stakes are used as supports for the plants, the main stem being loosely tied to each wire.



FIG. 5.—Tomato plants trained to stakes

tomatoes in crop is considerable, and the house must be so constructed that it will support it. In case the greenhouse is not so designed that it can be safely used as attachment for the wires supporting the plants, it is advisable to install anchor posts of pipes or angle-iron construction to serve this purpose. Such anchors may be placed at the ends of the houses and spaced as much as 100 feet apart provided they are substantially constructed.

TEMPERATURE AND VENTILATION

Day temperatures ranging from 70° to 85° F. are satisfactory for tomatoes. Night temperatures some 10 degrees lower are usually maintained. Sudden fluctuations as well as excessively low or abnormally high temperatures are extremely injurious to the crop. Success in the growing of greenhouse tomatoes requires the employment of houses capable of being maintained at the proper temperature even under the most unfavorable weather conditions.

Ventilation of the greenhouse-tomato crop is extremely important. The plants must be supplied with some fresh air even in very cold weather, and this must be accomplished without exposing them to drafts. Houses with the ventilators several feet above the plants and inclosing a large volume of air come nearest to meeting the requirements.

POLLINATION

Artificial pollination is extremely important and may be accomplished by means of a watch glass and wand. The watch glass is held under the flowers, the stems of which are tapped with the wand. This dislodges the ripe pollen, which drops upon the watch glass; and the glass is then lifted sufficiently to cause the stigma of the flowers to dip into the pollen on the glass.

Most growers go through the houses and jar the supports bearing the plants, thus dislodging the pollen and causing it to come in contact with the stigmas of the blooms. Hand pollination or the jarring method can be accomplished only when the air in the green-



FIG. 6.—A well-trained plant of a special strain of Sunrise, a well-known forcing sort

house is dry and the temperature rather high, which is usually about the middle of a bright sunny day.

WATERING

The tomato requires an abundance of water, but it must be applied with painstaking care. Most growers use a hose for the application of the water, and some employ the subirrigation method, using lines of 3 to 5 inch tile buried in the soil at close intervals, into which the water is run. This method avoids the objectionable puddling of the surface soil, which frequently follows the application of water by a hose or by flooding. Overhead irrigation systems seem to interfere with the ripening and distribution of the pollen.

Moderately frequent applications of water, which prevent the soil from drying out too much, are believed to be best. Excessive applications of water and poor ventilation, causing a damp atmosphere, are unfavorable to tomatoes. Careful management of the greenhouse, including the application of water, is essential to success with the crop.

INSECT ENEMIES ⁴

The commonest forms of insects which injure greenhouse tomatoes are the white fly, plant lice, and the red spider. The greenhouse leaf-tyer and the corn earworm may also gain access to the house but ordinarily pass unnoticed, although at times they may cause considerable damage.

GREENHOUSE WHITE FLY AND PLANT LICE

The presence of the white fly ⁵ in the greenhouse can be readily detected, as this small white insect usually takes flight when the plants are disturbed. The immature and adult forms develop and feed on the under sides of the leaves and obtain their food by sucking the plant juices. When the insects are abundant, this feeding causes the leaves to turn yellow and finally die.

The plant lice, or aphids, which usually attack tomatoes in the greenhouse are the spinach aphid ⁶ and the potato aphid. ⁷ These soft-bodied louselike insects feed on the under sides of the leaves and on the terminal shoots by sucking the plant juices. They develop rapidly, and unless checked serious damage may result.

CONTROL BY HYDROCYANIC-ACID GAS FUMIGATION

The cheapest and most effective method of controlling the white fly and plant lice in the greenhouse is by fumigation with hydrocyanic-acid gas. The gas is generated from sodium cyanid and, being very poisonous, may occasion serious injury to plants or human beings if care is not exercised in its use, although in careful hands and with a little practice this fumigant can be employed with excellent results. The grower who is interested in hydrocyanic-

⁴ Prepared by W. H. White, Truck-Crop Insect Investigations, Bureau of Entomology.

⁵ *Trialeurodes vaporariorum* Westw.

⁶ *Myzus persicae* Sulz.

⁷ *Macrosiphum solanifolii* Ashm.

acid gas fumigation may obtain full directions as to its proper use from the Bureau of Entomology, Department of Agriculture, Washington, D. C.

CONTROL BY NICOTINE FUMIGATION

Fumigation with nicotine is used extensively and with effective results for the control of plant lice, but the white fly is highly resistant, a heavy dosage being necessary to kill even the adults.

Nicotine for fumigation purposes is derived from several sources. The burning of tobacco stems is one of the oldest methods and is largely practiced in sections where the stems are readily obtained. The stems are burned in galvanized buckets or garbage cans, or placed in small heaps along the walks of the house. For even distribution of the material, place the containers or heaps at intervals of about 25 feet along the walks. Before burning, dip the stems in water for a moment and allow to drain. This will moisten them sufficiently to cause the material to burn slowly without flame and produce a dense, heavy smoke.

A more convenient method of fumigating with nicotine is by burning commercially prepared nicotine papers and nicotine fumigating dust.

Liquids containing "free" or volatile nicotine may be vaporized by applying the substance in a thin layer on a hot steam pipe by means of a paint brush or an oil can.

Tobacco stems and the commercial papers, fumigating dusts, and liquids containing volatile nicotine for fumigation contain variable amounts of nicotine, and it is, therefore, advisable to follow directions for their use as given by the manufacturer. The grower should carefully check results, and if the fumigation has not been effective the quantity of material used should be increased.

RED SPIDER

A small mite, commonly called the red spider,^s varying in color from light green to red, is one of the most difficult pests to combat. When present in small numbers, it feeds on the under sides of the leaves, but as it increases it attacks the entire plant, oftentimes covering it with a fine web. This mite apparently thrives under dry conditions and is usually more abundant on plants which receive but little water on the foliage.

A close watch should be maintained for the first appearance of this pest in order that it may be checked and not allowed to spread over the entire house. A spray consisting of about 2 pounds of soap and one-eighth pint of nicotine sulphate to 10 gallons of water should be thoroughly applied to the infested plants. During this application every effort should be made actually to cover the body of the mite with the spray. Syringing the plants with water washes the pests from them, and as many of the mites are unable to return to the plant this treatment usually results in an effective control. When the plants are in flower, however, such applications may interfere with the proper development and distribution of the pollen and must be employed with caution.

^s *Tetranychus telarius* L.

GREENHOUSE LEAF-TYER

The greenhouse leaf-tyer⁹ occasionally becomes troublesome on tomatoes in the greenhouse. The moth deposits its eggs in masses on the under side of the leaf. The worms, or larvæ, which hatch from these eggs are, when full grown, about three-fourths inch long, green in color, and marked with dark longitudinal stripes.

The normal habit of the worms when they are feeding is to fasten together the leaves and feed on the under sides. When abundant, they may devour the entire leaf.

If the attack is confined to a few plants, hand picking is the most convenient means of destroying the insect. When the attack is general throughout the house, spray or dust with an arsenical. The habit of the insect of feeding on the under side of the leaf makes it essential that the poison be applied to that portion of the plants.

CORN EARWORM

The corn earworm,¹⁰ a common pest on corn, beans, and tomatoes in the field, sometimes develops in the greenhouse and may cause considerable damage in its feeding upon the fruit. Hand picking the worms will usually prove sufficient to hold this pest in check.

DISEASES

Several diseases which attack the outdoor tomato crop seriously interfere with the production of greenhouse tomatoes. Greenhouse conditions are usually favorable to the development of serious diseases, which, if not controlled, will materially reduce the yield if not entirely destroy the crop.

DAMPING-OFF¹¹

Several damping-off fungi are responsible for severe losses of plants. The attacks of these fungi are encouraged by crowding in the plant bed, lack of ventilation, too much moisture, and too high temperature. Such conditions make the seedlings an easy prey to the causal organisms, which, however, may be controlled by sterilizing the soil with steam, hot water, or formaldehyde. The use of fresh soil as a control measure is to be recommended, but its sterilization is also advisable.

FUSARIUM WILT¹²

Without extensive control measures Fusarium wilt would soon bring upon the grower severe reductions in yield, if not the destruction of his crop. The disease clogs the water-bearing cells and manifests itself by stunting in growth, yellowish lower leaves, and finally a wilting and slow dying of the entire plant. During the progress of the disease the stems become discolored and when cut across have a dark-brown color between the bark and the pith. The wilt is soil

⁹ *Phlyctaenia rubigalis* Guen.

¹⁰ *Heliothis obsoleta* Fab.

¹¹ Caused by *Rhizoctonia solani* Kuhn and *Pythium debaryanum*.

¹² Caused by *Fusarium lycopersici* Sacc.

borne, and the greenhouse man has two methods of controlling it. He may sterilize his soil with steam, hot water, or a formalin solution, or he may use wilt-resistant tomato varieties and strains. Obviously, there would be little gained by using fresh soil free from the disease unless the beds, walls, benches, and other parts of the greenhouse were sterilized. Sterilization of the soil and the beds with live steam is the control method most generally followed.

The use of wilt-resistant sorts in the open is now well established. The Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, has developed several wilt-resistant varieties, such as Marvel, Norton, and Norduke. When Norton and Norduke are used for forcing, the water supply should be somewhat restricted, especially until the plants have begun to set fruit.

ROOT-KNOT¹³

The attacks of minute eelworms give rise to swollen knots on the roots of the plants, causing a yellowing of the leaves and a stunting of the plants, with a heavy decrease in yield and sometimes even death. The development of these parasites is greatly retarded by soil temperatures of less than 60° F. Sterilization of the soil with steam during the summer months is regarded as the most effective control for this disease. The soil must be heated to a temperature of about 210° F. for a depth of at least a foot, as the eelworms penetrate to considerable depths. They work under concrete walks and even under the walls and are difficult to control. Nematodes present one of the most difficult problems the greenhouse tomato grower has to meet.

OTHER LESS IMPORTANT DISEASES

STEM-ROT¹⁴

Stem-rot manifests itself by the wilting of the outer leaflets, followed by complete wilting of the leaves and death of the plant. Although it is not common in greenhouses it sometimes causes considerable loss. The main stem rots near the ground, where it is usually covered with a moldlike growth. Inside the stem somewhat elongated hard black bodies (sclerotia) are usually formed. Steam sterilization of the soil is the standard remedy.

LEAF-MOLD¹⁵

Leaf-mold is one of the commonest diseases affecting greenhouse tomatoes and appears as velvety spots on the lower sides of the leaves. These become brown in color and the leaves may curl up. Greenhouse tomatoes are frequently attacked by this disease, especially where the conditions in the houses are not suitable for the crop. With the application of water by subirrigation and ample ventilation little trouble should be experienced from this disease.

¹³ Caused by an eelworm, *Heterodera radiculicola* (Greef) Müller.

¹⁴ Caused by *Sclerotinia libertiana* Fchl.

¹⁵ Caused by *Cladosporium fulvum* Cke.

MOSAIC

Mosaic manifests itself by an abnormal leaf development of the affected plant. The leaves sometimes take on a fern-leaved shape, and a variegated or mottled effect is frequently noticeable. A rosette appearance is also often apparent. Although yields are undoubtedly reduced by this trouble, as a rule it does not cause the death of affected plants. It is known to be transferable from one plant to others by knives and other implements and by insects. Affected plants should not be trimmed or handled at the same time as healthy ones. Insect control is an obvious necessity.

BLOSSOM-END ROT

This disease sometimes causes serious losses to the greenhouse tomato crop. In its early stages it is characterized by yellowish spots around the dried blossom on the tomato, which enlarge and take on a dark color with a well-defined margin. The affected fruits are worthless, and as this rot is especially liable to attack the early portions of the crop the disease is an exceedingly destructive one. The exact cause of the trouble is not known, but it seems to be associated with droughty conditions in the soil. The use of soil well supplied with organic matter and of high moisture-holding capacity is believed to minimize the injury from this trouble.

Many other diseases cause occasional losses in the greenhouse-tomato crop. For more complete information on the subject, write to the Bureau of Plant Industry, United States Department of Agriculture.

HARVESTING AND HANDLING

Greenhouse tomatoes can usually be left on the plant until ripe and still be placed on the market and in the hands of the consumer in perfect condition. The high quality of a product handled with the dispatch possible with the greenhouse tomato adds materially to its popularity.

Most growers make a practice of gathering the tomatoes two or three times a week. Pickers use a basket or some other suitable container for transferring the product to the packing room, wheelbarrows or trucks running on the concrete walks usually being employed to expedite the handling of the crop. Most growers grade, sort, and pack according to size, quality, and market demands. The tomatoes are wrapped in tissue paper if to be shipped a considerable distance or to accord with market demands. Larger fruited sorts are usually wrapped singly, whereas the small forcing types are often wrapped three or four together.

Many kinds of packages are used. Some growers use a veneer basket, such as is shown in Figure 7, holding 10 pounds of wrapped tomatoes. The standard-bushel box is extensively used in the Boston, Mass., area. This box is $17\frac{1}{2}$ inches square and $7\frac{1}{4}$ inches deep, accommodating eight cardboard packages, each of which holds 6 pounds of tomatoes. The standard 4-quart cup, six of which are packed in a crate, is used by some growers. Corrugated-cardboard

boxes holding a few pounds and other kinds of containers are also employed. The particular kind selected is determined by the size of the tomatoes and by market demands.

YIELDS

Fall-grown tomatoes seldom yield as heavily as the spring crop, which is produced when conditions are more favorable. A yield of 4 pounds per plant is considered good for the fall crop. As much as 10 pounds per plant is sometimes secured in spring. Tables 2, 3, and 4 show yields secured with various varieties grown in the greenhouses at the Arlington Experiment Farm, Va. A grower in the Rochester, N. Y., area secured a yield of 5,000 pounds in a house

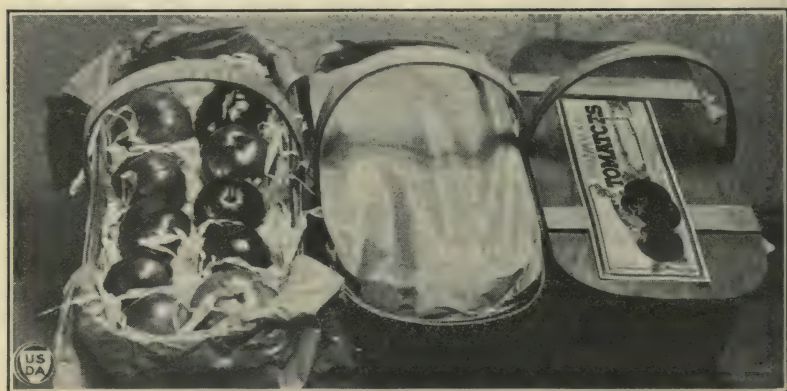


FIG. 7.—Ten-pound veneer baskets largely used for packing and marketing greenhouse tomatoes

about 30 by 180 feet. This yield is perhaps higher than could be expected under less favorable conditions.

RETURNS

Gross returns range from as low as 10 cents a pound to as high as 50 cents. The net returns depend on such factors as the amount of the investment in greenhouses and other equipment and the cost of fuel, labor, manure, fertilizer, packages, and other widely varying factors.

The public is rapidly learning to appreciate the superior qualities of greenhouse-grown tomatoes, which are more popular than the other prominent forcing crops but require great skill to produce. The requirements are now well understood by most greenhouse men, and it is probable that the industry could, with profit, be still farther expanded.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

November 28, 1924

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U. S. DEPARTMENT OF
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FARMERS' BULLETIN No. 1432

CULTURE of PIMA
and
UPLAND COTTON
in ARIZONA



U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN NO. 1111

EXTENSION OF COTTON CULTURE into the drier regions of the Southwestern States is one of the consequences of the invasion of the eastern Cotton Belt by the boll weevil. Cotton already is the chief product of several of the irrigated valleys, and a large increase of production is to be expected if high prices continue.

This bulletin describes the methods used in growing cotton in the Salt River Valley, Arizona, including the selection and preparation of the land, planting, thinning, irrigation, cultivation, and the harvesting of the crop. The information has a general application to the irrigated districts where cotton is grown in New Mexico, Arizona, and California.

Washington, D. C.

Issued August, 1924

CULTURE OF PIMA AND UPLAND COTTON IN ARIZONA¹

By O. F. COOK, *Bionomist*, and R. D. MARTIN, *Assistant, Office of Crop Acclimatization and Adaptation Investigations, Bureau of Plant Industry*

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COTTON is now a major crop in several of the irrigated valleys of the Southwestern States. Costs of producing and marketing are higher under western conditions, but it is possible to secure large yields of superior fiber. Precautions are needed in the selection of land, in maintaining supplies of good seed, and in the cultural treatment of the crop. Failures are usually caused by neglect of cultural operations or of proper irrigation. An understanding of the requirements of the crop is essential to a better utilization of the resources of production. The object of this bulletin is to describe cultural methods which have proved successful in the Salt River Valley and adjacent districts, including the preparation of the land, irrigation, and cultivation of the crop.

The information is based primarily on experience in growing the Pima variety of Egyptian cotton, but the requirements of Upland cotton in the irrigated southwestern valleys are not essentially different. Regarding some features in which slight differences have been observed, the treatment of the two types has been discussed separately.

SELECTION OF A VARIETY

Commercial conditions have not been favorable for Pima cotton since the war period, chiefly on account of the fact that large importations of cotton could be made from Egypt at relatively low prices because of the restricted use of Egyptian cotton in Europe. Many farmers have stopped growing Pima and are planting Upland cotton. Prices of Egyptian cotton did not advance in the seasons of 1922 and 1923 in proportion to the advance in Upland cotton, so that

¹This bulletin is largely a revision of Farmers' Bulletin 577, Growing Egyptian cotton in the Salt River Valley, Arizona, by E. W. Hudson, and of material from other publications, including—

Camp, W. B. Cotton culture in the San Joaquin Valley in California. U. S. Dept. Agr. Circ. 164, 22 p., illus. 1921.

King, C. J. Crop tests at the cooperative testing station, Sacaton, Ariz. U. S. Dept. Agr. Circ. 275, 46 p., illus. 1923.

Water-stress behavior of Pima cotton in Arizona. U. S. Dept. Agr. Bul. 1018, 24 p., illus. 1922.

Martin, R. D., and H. F. Loomis. Summer irrigation of Pima cotton. Jour. Agr. Research, v. 23, p. 927-946, illus. 1923.

the growing of Upland cotton is likely to continue until the market outlook for Pima is definitely improved. Also, it is believed by many farmers that Upland cotton is much more productive than Pima.

A large acreage was planted to Upland varieties of cotton in the Salt River Valley and adjacent districts in 1922 and 1923. High yields were secured in many cases and low yields in others. In a series of side-by-side comparisons of Pima and Upland varieties conducted on very fertile soil at the United States Field Station, Sacaton, Ariz., for the last three seasons, 1921-1923, the Pima variety yielded equally well with Lone Star, Acala, Durango, Mebane, and Harts-ville, though the last two varieties were included for only one season. In some comparisons with Pima at Sacaton pronounced differences have been shown in favor of Acala, and cases are reported in the Salt River Valley of lands where previously Pima had not given good yields, but where satisfactory crops of Upland cotton were produced in 1922 and 1923. These soils may continue to give better yields of Upland cotton than of Pima, or results may be different in seasons less favorable to the Upland varieties.

The highest yields are to be expected from Upland cotton when sufficient numbers of bolls are retained. The larger size of the bolls is an advantage for Upland cotton, but it is often counteracted by a greater tendency to shedding, so Upland varieties may yield less than Pima in adjacent plantings. To determine the relative productiveness of the two types of cotton will require careful comparison and checking of results for several years to cover the range of seasonal conditions.

Though experience with Pima cotton has shown the need of holding to one variety, so that supplies of pure seed may be developed and maintained, there has been much diversity of interest and opinion regarding the several Upland varieties represented in the valley.

It might not be impracticable to maintain supplies of pure seed of Pima and an Upland variety in the Salt River Valley, since the two types of cotton, as well as hybrids between them, are easily distinguishable. Hence, any mixing or crossing could be detected readily in the inspection and roguing of the seed fields. But it would be a much more difficult problem to maintain supplies of good seed if several Upland varieties continue to be grown in the valley. Mixtures or hybrids among the more similar Upland varieties could be distinguished only by breeding experts, so that effective isolation and roguing of several seed stocks would be very difficult and expensive, if not entirely impracticable.

The Acala variety, acclimatized in recent years from Mexico, apparently is well adapted to the conditions of the southwestern irrigated valleys, and supplies of good seed are obtainable in Arizona and California, so that there is no occasion to import seed from weevil-infested regions.

SELECTION OF LAND FOR COTTON

Cotton can be grown successfully on practically all of the irrigated lands in the Salt River Valley and adjacent districts. A fairly rich, deep, sandy loam soil is regarded as the best type of land because the cultural operations and irrigation can be handled to the best ad-

vantage. Other types of soil will grow good crops of cotton in proportion to their fertility, texture, and other cultural qualities. Soils that are too heavy take water very slowly, while very light soils lose water too rapidly, making it more difficult to grow good crops of cotton.

While some of the raw desert land has made good crops, better cotton can be grown, and at a lower cost, on land that has been in alfalfa. Most of the new land does not hold the water so well and requires more frequent irrigations; also, much of the new land is very uneven with spots of light soil which have to be irrigated separately if a uniform growth is to be maintained.

Alkali soils often grow excellent crops of cotton, though the plants may be injured if the salts are permitted to accumulate in the surface root zone during the period of active growth. The chief difficulties encountered on alkali soils are in securing a stand and in keeping the plants sufficiently watered in the fruiting period. Seedling plants are easily killed by salts that accumulate in the surface soil occupied by the roots, so that the stand frequently is poor. Also, alkali soils are often less pervious and take water slowly. After the fruiting stage is reached frequent flooding is necessary to keep the plants from being checked and shedding most of the crop. Some lands with a high water table may show salt on the surface and yet be able to grow good crops of cotton. In such cases no irrigation may be necessary during the entire season except the preliminary application before planting. It is not advisable to plant cotton on land that has many hard, impervious spots, locally known as "slick spots," because of uneven stands and difficulties of uniform irrigation.

SLOPE OF THE LAND

Land that is well leveled will require less water and will produce the most uniform cotton. The best grade to be given will depend somewhat upon the character of the soil, a steeper grade being permissible in light soils, which take water readily. Heavy soils will not become thoroughly wet unless the water can be held on the surface for some time or unless small heads of water are run for longer periods. Land that has too much slope is difficult to irrigate properly, and the fields are likely to dry out in spots, which must be irrigated separately if injury to the cotton is avoided. Where alfalfa land is put in cotton it is often advisable to change the plan of irrigation and bring the water from a different direction in order to secure a lighter grade.

PREPARATION OF THE LAND

Methods of preparation depend largely upon the condition of the land, whether weedy or clean, and upon the nature of the preceding crop. For land overrun with Johnson grass, preparation should begin in August with a shallow plowing, only 2 or 3 inches deep, then allowing the soil to dry out thoroughly. This is followed by a thorough disking and harrowing, thus dragging as many of the roots to the surface as possible. A spring-tooth harrow may be used to advantage in this work. During November or December another shallow plowing is given, and the soil is then pulverized by disking and harrowing. At this time the fields are gone over in both direc-

tions with orchard cultivators or similar tools having long teeth, to bring as many of the grass roots as possible to the surface, where they may be raked together and burned or hauled off the field. The land is then left fallow until the latter part of February.

In preparing to plant cotton on alfalfa land which is not overrun with Bermuda or Johnson grass, the same general plan can be followed, but with less disking, harrowing, or cross-plowing. If alfalfa land is plowed 2 or 3 inches deep, turned up to the sun until thoroughly dry, and later plowed 6 to 8 inches deep, very little alfalfa will survive to give trouble during the following season. Though alfalfa land may be prepared at any time prior to the planting season, it is better to plow first in October or November and again in January. Specially designed moldboard plows can be used to advantage in breaking up old alfalfa fields on sandy or loamy soils, in order to prevent subsequent growth from the roots.

In preparing cotton land for planting again to cotton, a stalk cutter should be used to chop the stalks into small pieces. Stalks that are too rank and woody to be broken by a stalk cutter are dragged down or cut by hand, then raked together and burned. The land should then be plowed, disked, and harrowed until in good tilth, when it may be left until planting time.

Bermuda grass is not so hard to eradicate as Johnson grass. It is possible by shallow plowing in November or December, followed by thorough disking and harrowing during the winter, to put Bermuda grassland in shape for cotton, if free from Johnson grass. Freezing will help to kill the roots if the winter preparation is thorough. Two or three weeks before planting, the land should be plowed from 4 to 6 inches deep and thoroughly pulverized.

To keep the Bermuda grass from reestablishing itself, regular cultivation must be kept up until the cotton plants are large enough to shade the ground. It may be necessary to chop out the grass and weeds in the rows at the time the cotton is being thinned, and in bad cases once or twice afterwards.

PREPARATION OF THE SEED BED

Thorough preparation of the seed bed during the winter gives the best prospect of a large crop, and less work is required during the summer.

Land previously in cotton or grain can usually be put in satisfactory condition by one plowing, while land previously in alfalfa should be plowed twice. It depends upon the kind and condition of the soil whether a double plowing is necessary to put the land in good tilth or whether this can be done by a single plowing, with double disking and double harrowing.

During the latter part of February, borders are thrown up about 2 rods apart. Before planting time the land should be flooded and then disked and harrowed as soon as sufficiently dry.

If the soil is very heavy it may be necessary to plant on ridges or beds, for the reason that land of this character may have to be irrigated in order to germinate the seed. The beds may be made $3\frac{1}{2}$ feet wide and 8 inches high, but should be reduced to not more than half this height before planting. A smoothing drag can easily be constructed of 2 by 6 inch scantling that will take two or three beds

at a time. It should carry weight enough to drag off the surface clods and get down to the moist soil. Bedding is usually unnecessary, since if pulverized sufficiently, well irrigated, and placed in good tilth before planting, most of the soil of the Salt River Valley will hold moisture enough to bring up the seed without further watering.

TIME AND METHOD OF PLANTING

No definite date for planting can be set, since much depends upon the seasonal conditions. The rule is that cotton should be planted as early as possible with assurance of securing a stand. Early planting is desirable not only to secure the advantage of the longer season but because the young plants are likely to show more normal habits of branching and fruiting if very hot weather is not encountered during the early stages of growth. Experiments conducted with the Pima variety at Sacaton, Ariz., from 1917 to 1922, inclusive, indicate that the best time for planting is about the middle of March. But in some seasons cold weather or even frosts may continue in March, and it is better to wait two or three weeks longer, or until the weather is favorable. If the ground is too cold the seeds rot or germinate very slowly, and many of the seedlings are unable to push through.

With Upland varieties, such as Mebane, Acala, Durango, or Harts-ville, there is less need to plant early, since Upland cotton requires less time to develop and mature a crop. In some cases good yields of Upland cotton have been secured from fields that were planted after the first of June. Thus it is possible for Upland cotton to follow winter crops of grain or truck. However, early planting of Upland cotton varieties is advised when possible, so that a fair crop of bolls may be set on the lower branches before hot weather.

On land enriched by previous crops of alfalfa, cotton should be planted in rows $3\frac{1}{2}$ or 4 feet apart. On new desert land or land that has been in grain but not in alfalfa the rows need not be more than 3 to $3\frac{1}{2}$ feet apart. The wider rows are recommended so as to permit the sunlight to reach the lower branches even when the plants grow rather large, as they usually do on fertile soil with plenty of water.

Satisfactory results may be obtained with either a 1-row or a 2-row planter, the latter giving a more uniform depth of planting.

Except in very heavy soils flat planting is to be recommended, using a special shoe or lister attachment to push away dry soil and reach a moist seed bed. This device is very simple and easily made, either of wood or of iron. It fits down over the original planter shoe and is readily adjusted. The loose dry surface soil is pushed back and the seed placed in moist earth at a uniform depth (fig. 1). The double-disk device with which some types of planters have been equipped in recent years has also been found very effective for this purpose, though somewhat more expensive.

The depth of planting is varied to meet the conditions. For normal early plantings seed should be not less than 1 inch or more than 2 inches deep. If the soil is in perfect condition and there is moisture enough to insure prompt germination and bring the young plants above ground, 1 to $1\frac{1}{4}$ inches is a sufficient depth to plant. Later plantings may need greater depths, from 2 to 2 $\frac{1}{2}$ inches, especially on light sandy soils that dry out quickly. Only as much land

should be irrigated at one time as can be prepared and planted before the soil becomes too dry to germinate the seed. Otherwise, a poor stand is likely to result. Except on heavy soils it is important that the harrow, drag, and planter be as close behind the disk as possible. If the soil is left in clods instead of being pulverized, the upper layers are likely to dry out very rapidly, especially when high winds occur, which are frequent at planting time. Many of the poor stands obtained in some seasons can be attributed to the drying of the soil in the seed bed.

To insure a good stand in early plantings it is advisable to use 30 to 40 pounds of seed to the acre. In later plantings under ordinary conditions 25 pounds will give satisfactory results. Some growers

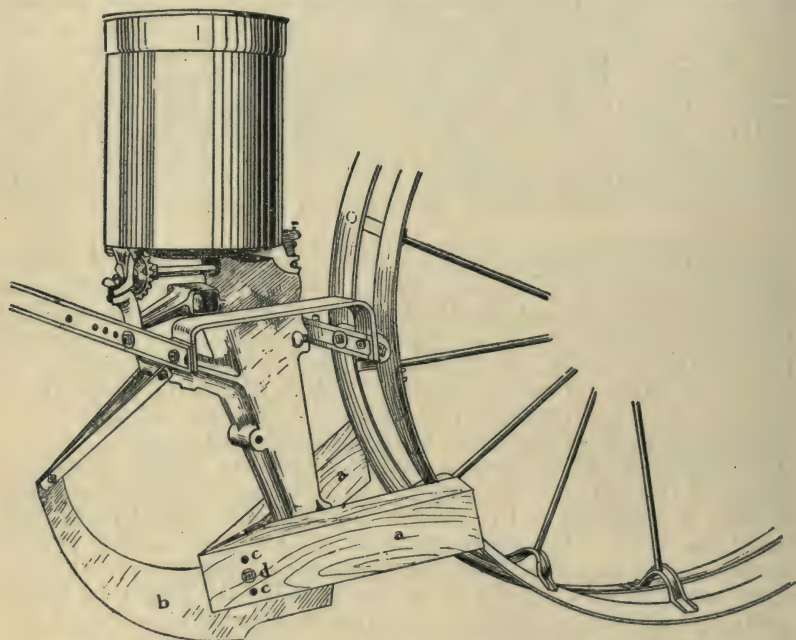


FIG. 1.—A planter attachment used to push away the dry surface soil: *a, a*, The 2 by 4 wings; *d*, bolt used to fasten the wings to the shoe. Additional holes, *c, c*, can be put in the wings, so that they may be lowered or raised as desired, and the depth of covering the seed may be regulated in this way

use only 12 to 15 pounds of seed per acre and get fairly good results, though there is less assurance of a regular stand. Several seedlings together may lift a crust from which a single seedling could not emerge.

It is not advisable to flood the land after planting, because a crust is formed and the young plants may be unable to break through. Beds are used on very heavy lands and water run in the furrows, so that the ridges are moistened by seepage and the formation of a crust is avoided.

CULTIVATION

A shallow cultivation is given as soon as the plants are well out of the ground, to break any crust which may have formed, to dry

and warm the surface soil, and to kill the weeds. It often is possible on clean land to make the first cultivation with a drag or spike-tooth harrow. Otherwise, a disk cultivator is preferable for the first or first two cultivations. For later cultivations small shovels and sweeps are preferable, because they kill more weeds and leave the land in better condition.

As soon as there is no danger of covering the plants, the soil should be gradually worked toward them at each cultivation. Some of the weeds are covered, and a small ridge is thrown up along the row, which makes it easier to control the later irrigations. After each irrigation the ground should be stirred until the plants are too large to be cultivated. More frequent cultivation is required in some fields to keep down weeds and maintain a good mulch on the surface. This is especially true early in the season, when irrigations are likely to be several weeks apart.



FIG. 2.—Normally developed Pima cotton plants at an early stage soon after thinning, with the first fruiting branches not yet showing beyond the leaves

On land that breaks into large clods following irrigation, wooden rollers, or "cultipackers," can be used for crushing the clods and putting the soil in proper tilth. A riding cultivator may be used until the plants are too tall, when a 1-horse walking cultivator is required. The late cultivations also should be shallow, so as not to interfere with surface roots.

SPACING OF PLANTS IN THE ROWS

Thinning to 12 or 14 inches is customary, the wider spacing of former years being generally abandoned (fig. 2). The thinning, more often called "chopping," is usually done when the plants are about 6 inches high. Good results are secured from this method under favorable conditions in the Salt River Valley.

Experiments have shown that larger yields may be obtained with closer spacings than 12 inches, especially under conditions where the plants grow rank and have too many vegetative branches that close the lanes between the rows, as well as at the other extreme where the plants remain small and restricted in size. Plants spaced

to 6 or 8 inches or two plants per hill at 12 inches have better chances of setting good crops under either of the extreme conditions. In open stands with the plants at an average distance of 2 to 4 inches apart in the rows, thinning may be unnecessary, or it may even reduce the yield, as shown in several experiments with Upland cotton in Texas.

Very early thinning, before the plants are 5 or 6 inches high, is not advisable. In the seedling stage the mutual protection is an advantage, so that the young plants make better growth and there is less danger of losing a stand through sand storms, sore-shin, or cutworms. On rich alfalfa land it is better to delay thinning until the plants are 10 or 12 inches tall, except that with spacings of 6 inches or less or with two or more plants in a hill there is no occasion to delay thinning.

The advantage of closer spacing and later thinning is explained by the fact that the vegetative branches or side stalks are suppressed, so that the plants are more upright and the lanes between the rows remain open during the season. The individual plants are smaller and bear fewer bolls per plant, but the yield is made up by more plants per acre. Moreover, the crop is easier to pick and the bolls open earlier where rank growth is avoided, so that frost injury is reduced.

The same principles apply to the thinning of the Upland cottons as to Pima. Under favorable conditions and with the long growing seasons of the Salt River Valley good yields may be had with any spacing from 3 inches to 2 feet, but it does not appear that the wide spacings offer any definite or regular advantages to compensate for the serious losses that often result when the plants grow too large and crowded and fail to mature a crop before frost.

Farmers who plant cotton late, after winter grains or truck crops, are advised to pay particular attention to spacing and thinning. Late-planted cotton is more inclined to rank growth, and if very luxuriant it may fail to set fruit or may produce only a late crop that fails to open before frost. It appears logical to argue that because late-planted cotton is likely to grow rank, the plants should have wider spacing in the rows, but in reality the danger of rank growth renders close spacing more necessary with late plantings. To get the maximum crop from late-planted cotton the plants should stand only a few inches apart, to insure a suppression of the vegetative branches and induce a quick setting of a crop of bolls.

EARLY IRRIGATION

If the soil contains the proper amount of moisture when the seed is planted and is well cultivated, no irrigation may be required for six weeks or two months after planting. Then a light furrow irrigation may be given, followed by cultivation as soon as the ground is dry enough to work.

If the field is not in good condition after one cultivation it should be gone over a second time as soon as possible; in any event within 10 days or two weeks. Under ordinary conditions it will not be necessary to irrigate again for three or four weeks, when another light irrigation should be given, followed by a thorough cultivation. These two irrigations should carry the crop until about July 1. It

is understood that cultivation should always follow any rains that may come.

It may be necessary to irrigate more frequently on new land, which usually will not retain moisture so well as land that has been in crop, particularly alfalfa. New land usually has to be irrigated at least three or four times before July 1. Also some old land may require an extra irrigation during this period if serious wilting occurs. But wilting of some of the plants during the early stages of development is not conclusive evidence that a general irrigation is needed. Even with plenty of moisture in the soil the young plants may be wilted by warm weather following a cold period. When the change from cool to hot weather is very abrupt and the difference between day and night temperature is great, the plants may require two or three days to adjust themselves.

Irrigation is not required so long as the plants are growing vigorously. With Pima cotton the lack of water is indicated suf-



FIG. 3.—Normally developed Pima cotton plants at the beginning of the fruiting stage, when summer irrigations begin. Note the development of fruiting branches and the suppression of vegetative limbs.

ficiently in advance by the wilting or drooping of the leaves in the hot hours of the day, though irrigation may be delayed until the leaves show signs of wilting before noon. A little wilting on a very hot day does not necessarily indicate a need of irrigation, especially if the weather has turned hot suddenly after a cool period.

The reason for irrigating sparingly during the first part of the season is to avoid the too rapid growth of the plants. If the plants enter upon a rank, woody growth they are likely to maintain this tendency throughout the season at the expense of fruitfulness (figs. 3 and 4). More attention should be given to the spring treatment of cotton, so as to have the plants in a normal fruiting condition when summer irrigations begin. The treatment cotton receives before flowering begins is undoubtedly reflected in all of the subsequent behavior of the plants and is a factor in determining the water requirements during the fruiting period. When a normal fruiting condition is attained, the summer irrigation problems are simplified, since the plants are not so easily forced into rank growth by the

application of water in excess of the actual requirements. (See fig. 3.)

SUMMER IRRIGATION

The application of water in July, after the early stages of growth are past and the plants are flowering and fruiting, is determined by the need of the plants. The object is to maintain regular growth and productiveness, as shown by abundant flowering and by little or no wilting of the leaves in the middle of the day.

In addition to the wilting of the leaves, the position of the flowers on the plants is another guide in determining the need of water. As long as the plants are growing well, the flowers are low down and come near the top only when the growth slackens. Growth should continue during July and August so that the flowers are



FIG. 4.—Pima cotton plants growing somewhat too rank, as indicated by the larger leaves and less prominent fruiting branches in comparison with Figure 3, as well as by the development of vegetative branches from the lower joints of the stalks

kept well down on the plants, the top of the field showing largely leaves and squares, with relatively few flowers in sight. (Fig. 5.) When the flowers can be seen in the tops of the plants and a decided yellow color is noted in looking over the field, it is evident that irrigation has been postponed too long.

Another method that growers frequently use for determining the need of watering a field of cotton is to watch the plants on the lighter spots of soil, and when these plants show wilting before noon the whole field is irrigated. But care should be taken not to overgrow the cotton in the better soil in an effort to save that on a few sandy spots.

In comparison with adjacent plantings of Upland cotton it has been noted that the leaves of Pima cotton wilt more quickly and that the Upland cotton is more adversely affected by wilting, as shown by the heavy shedding rates of squares and young bolls.

Thus it appears that greater care may be needed in the irrigation of Upland cotton, after flowering has begun, to avoid the stress condition that is indicated by wilting of the leaves.

A definite indication of the need of water in Upland cotton that will serve to prevent wilting and yet not "overgrow" the crop has not been detected, but there are several points that may be useful to inexperienced growers in determining the need of water. After flowering begins the plants should grow steadily, but not luxuriantly. The upper leaves should be of medium size, rather deeply lobed, and of a leathery texture, instead of the plants being forced, so that they develop large, coarse, broad-lobed, "elephant-ear" leaves. The squares at the top should be rather prominent in a well-grown plant



FIG. 5.—Normally developed Pima plants at the midseason stage. Note the medium-sized leaves and open foliage, the branches all of the fruiting type with numerous squares and young bolls

instead of being mostly hidden by the leaves, as on large luxuriant plants.

Another plant character to be observed in Upland cotton is the reddish color of the main stalk and the stems of the leaves, which increases with the age of the parts. Thus the approach of the red color to the terminal bud shows that growth is being checked and quite probably that water is needed. The reddish coloration of the stalk should be kept 3 or 4 inches from the top.

In less definite ways the general appearance of a field will show the experienced farmer that the plants are not in vigorous growth, and such impressions may be confirmed by examination of the soil. If the soil in the upper 2 feet is dry in appearance and will not hold its shape when squeezed by the hand, it is generally time to irrigate.

Wilting is permitted by some growers of Upland cotton who believe that it is advisable to check the development of the plants, since an excessive growth may cover the field with a dense canopy of foliage and greatly restrict the production of a crop. The growing of Upland cotton on very fertile soils is rather a hazardous undertaking.

After an irrigation any depressions that hold water should be drained. Standing water is not only bad for the cotton but injures the land. Some farmers reduce their yields materially by giving excessive irrigation on heavy land and allowing the excess water to stand in their fields.

IRRIGATION IN THE PICKING SEASON

Serious damage may result from withholding water too soon in the fall. It is often desirable to irrigate once after the first picking, and sometimes twice. Though vigorous growth of the plants is not desirable after the first of September and less water is needed as the days shorten and the weather becomes cooler, enough water should be used to keep the plants in a healthy condition and to take full advantage of favorable weather for maturing as many bolls as possible. Undoubtedly a lack of water may force an earlier opening of some of the bolls, but any severe check that wilts the leaves and forces the bolls to open prematurely is likely to be very injurious, especially if the growing season continues into October or November, as often occurs in the southwestern valleys.

The fact that picking may be advanced somewhat by withholding water is not a sufficient reason for checking the development of the crop at a period that may be most favorable for production. Even in relation to picking, nothing may be gained, for if the plants are checked and wilted many of the bolls are poorly developed and fail to open normally, so that picking becomes more difficult and the fiber is inferior.

Since the soils are seldom uniform, many fields contain spots where the plants need water, although a general irrigation may not be necessary in the latter part of the season. By throwing a ridge across the field and turning a small head of water down between the rows the spot that is drying out may be irrigated without wetting the rest of the field. Of course, such attention to the needs of the crop entails a little extra care and expense, but the increased yield and more uniform quality will more than offset the additional cost.

As the soil and climatic conditions govern to a large extent the number of irrigations to be given during the growing season, they also determine how late water should be applied. If the fall is cool, the bolls that are set after the middle of September are likely to be killed by frost. The period of boll development early in the season is only about 50 days, from the flower to the open boll, whereas later in the season the period of development is gradually lengthened to 70 or 80 days. If the soil is heavy and the cotton has grown very rank, special caution may be needed to avoid an excess of moisture late in the season, since the bolls are slow to open while the cotton is in a state of vegetative vigor. Also the bolls near the ground are likely to mildew or rot under a heavy growth of leaves.

PICKING

Cotton differs from many farm products in being less perishable and not requiring to be harvested immediately, as soon as the bolls open. (Fig. 6.) However, to get the best results picking should begin just as soon as enough cotton is open to be worth while for the pickers, which with Pima cotton is when there are 8 to 10 open bolls per foot of row. In the earlier fields picking begins about the middle of September, but many late-planted fields are not ready to pick until the middle of October.

To get the highest grades three pickings should be made and each picking kept separate, since marked differences may be found when the grading is carefully done. The later pickings usually con-



FIG. 6.—Normally developed and productive Pima plants at the end of the season

tain more broken leaves and other particles of trash, which tend to lower the grade. Also the first or the last picking may contain damaged or immature fiber which is weak and of inferior grade. Cotton from frost-killed bolls should never be mixed or ginned with the earlier pickings.

Light frosts may occur that kill the leaves but do not freeze or damage the bolls. Such frosts may serve a useful purpose, especially in rank cotton with dense foliage. After the leaves are frosted the fields dry out and the bolls open.

After a freeze that kills the bolls the fields should be gone over as soon as possible to gather the cotton from the bolls already open, before the damaged bolls have opened. If the stained and damaged fiber is picked with the good cotton all of the late picking must be sold as a lower grade, which may be a serious loss.

Cotton which has suffered severely for the lack of water or is otherwise damaged should also be picked and ginned separately, to avoid injuring the grade of the general crop.

To command the best price, careful picking is necessary to keep the cotton clean. This is especially true of Pima Egyptian cotton, and pickers who have handled only short-staple varieties may object at first to the care that is necessary to keep the Pima cotton clean. But after a little experience they find that it is not difficult to keep out most of the broken leaves and bracts.

Cotton should not be piled on the ground or left exposed in the field but housed or covered in a dry place. A little rain while the cotton is still in the bolls does little damage, but a heavy rain on a pile of cotton may result in staining and seriously injuring the grade. The dust and soil discolor the wet cotton so that it may be stained several inches deep. Cotton should not be picked when wet; if slightly damp it should be spread in the sun to dry. If thoroughly dry, seed cotton can be stored indefinitely without danger of heating.

GINNING

Roller ginning is necessary for Pima cotton. The process is slower and more expensive than saw ginning but is essential to marketing the lint as a superior long-staple cotton. One of the difficulties now recognized in connection with Pima cotton is that different equipment and methods of handling the cotton have been followed in the various ginning establishments, so that the commercial samples and bales have not had a uniform appearance. This undoubtedly has interfered with the marketing of the cotton to the best advantage.²

Care is needed by the ginner to avoid rolling and tangling the cotton, which makes it "rough" or "ropy" in the sample. Pima cotton should not be run through more than one set of "picker roll cleaners" and the "cleaner feeder." For cleanly picked cotton only the feeder cleaner is needed.

The gin stands should be kept in repair and adjustment, to turn out a uniform product. Loose machinery that cracks seeds or allows ginned seeds or unginned seed cotton to become mixed with the lint will lower the commercial grade and reduce the price to the farmer.

The bales should be completely covered with heavy burlap bearing the necessary label, and an adequate sample should be taken from each bale before it goes to the press, so that buyers will not have to cut the bales to establish their grade and staple.

² Willis, H. H. Utilization of Pima cotton. U. S. Dept. Agr. Bul. 1184, 26 p., illus. 1923.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1433

CULTIVATED
GRASSES OF
SECONDARY
IMPORTANCE



THIS BULLETIN contains information, especially for farmers, regarding 19 grasses of secondary agricultural importance in the United States. It will indicate to each farmer which of these grasses is likely to be of value in his section.

Each grass is illustrated, and agronomic and botanical information concerning it is given.

Washington, D. C.

Issued February, 1925

CULTIVATED GRASSES OF SECONDARY IMPORTANCE

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THE GRASSES herein described and illustrated are all of some agricultural or horticultural value in the United States. Not one of them is of outstanding importance except in a limited area. Some of them are sure to reach greater economic importance as they become better known and their value is more appreciated.

All of the grasses herein described, except slender wheatgrass, were introduced from some other country. All of the grasses of the highest importance in the United States discussed in a previous bulletin (see Farmers' Bulletin 1254, "Important Cultivated Grasses") are from some other region than the United States, and with one exception all are natives of the Old World. Just why introduced grasses succeed under cultivation so much better than native grasses is one of the mysteries of nature. Probably there are secrets concerning our native American grasses not yet unraveled. Some of them are admirable in respect to growth, texture, and palatability, but they seem unable to hold the ground against more aggressive alien species.

BROMEGRASS

Brome grass (*Bromus inermis* Leyss; fig. 1) is also known as Hungarian brome, smooth brome, awnless brome, Russian brome, and Austrian brome. It is native from central Europe to China. The earliest cultivation reported was in 1769 as a pasture grass, but except in Hungary and Russia it never attained much importance in Europe. It was first introduced in the United States about 1884 and soon met with high favor as a grass for the drier farming regions



FIG. 1.—Bromegrass (*Bromus inermis* Leyss): 1, Plant showing habit (about one-fifth natural size); 2, a panicle (somewhat reduced); 3, spikelet (much enlarged)

of the West (fig. 2). The most extensive culture is in the Dakotas, Montana, and western Canada, but since 1910 the acreage in this grass has probably not increased.

Bromegrass is best adapted to regions of rather light rainfall and low or moderate summer temperatures. It has never succeeded as well in the East as in the West. The best growth is made on clays or clay loams, but it succeeds fairly well in sandy soils. The roots penetrate 5 to 6 feet into the soil. No other cultivated perennial grass has yet been found which withstands drought conditions so well. Even in the most severe winters no injury from the cold seems to occur. Bromegrass is usually sown in spring on well-prepared land, using from 10 to 20 pounds of seed per acre. The yield of hay the first year is usually small, good the second year, and best the

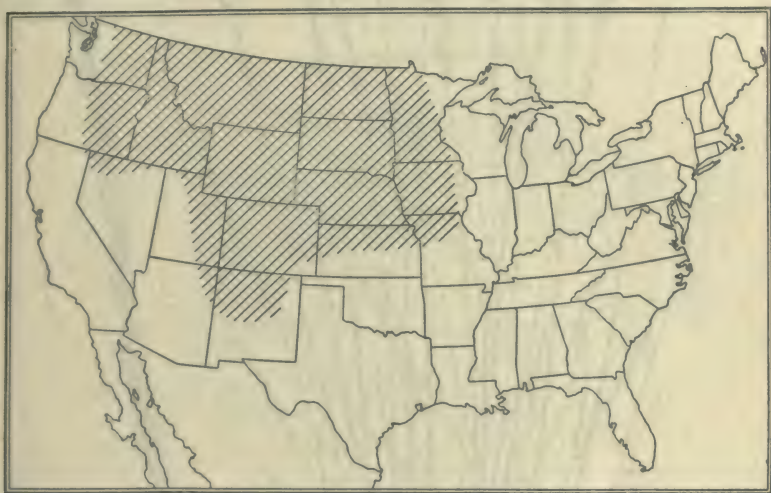


FIG. 2.—Region of the United States in which bromegrass is most valuable

third. Thereafter the yields decrease markedly unless the fields are specially treated. The yield of hay ranges from $1\frac{1}{2}$ to $3\frac{1}{2}$ tons per acre. Where the higher yields are secured two cuttings are made in a season.

After the third year bromegrass is said to become sod-bound. By loosening the soil the yields will be increased. This may be done by plowing the grass shallow in spring or in fall, by plowing deeper in spring and sowing oats, or by plowing in fall and sowing small grain. In all cases the grass is markedly invigorated.

Bromegrass is also excellent for pasture, being one of the most palatable of all grasses. It is really more valuable thus used than for hay, but it will not pasture as many animals as does sweet clover. Sometimes it is mixed with sweet clover for pasture.

Seed is produced in the Dakotas and western Canada. Yields are from 250 to 600 pounds per acre. A bushel weighs from 10 to 20 pounds. One pound contains about 137,000 seeds.

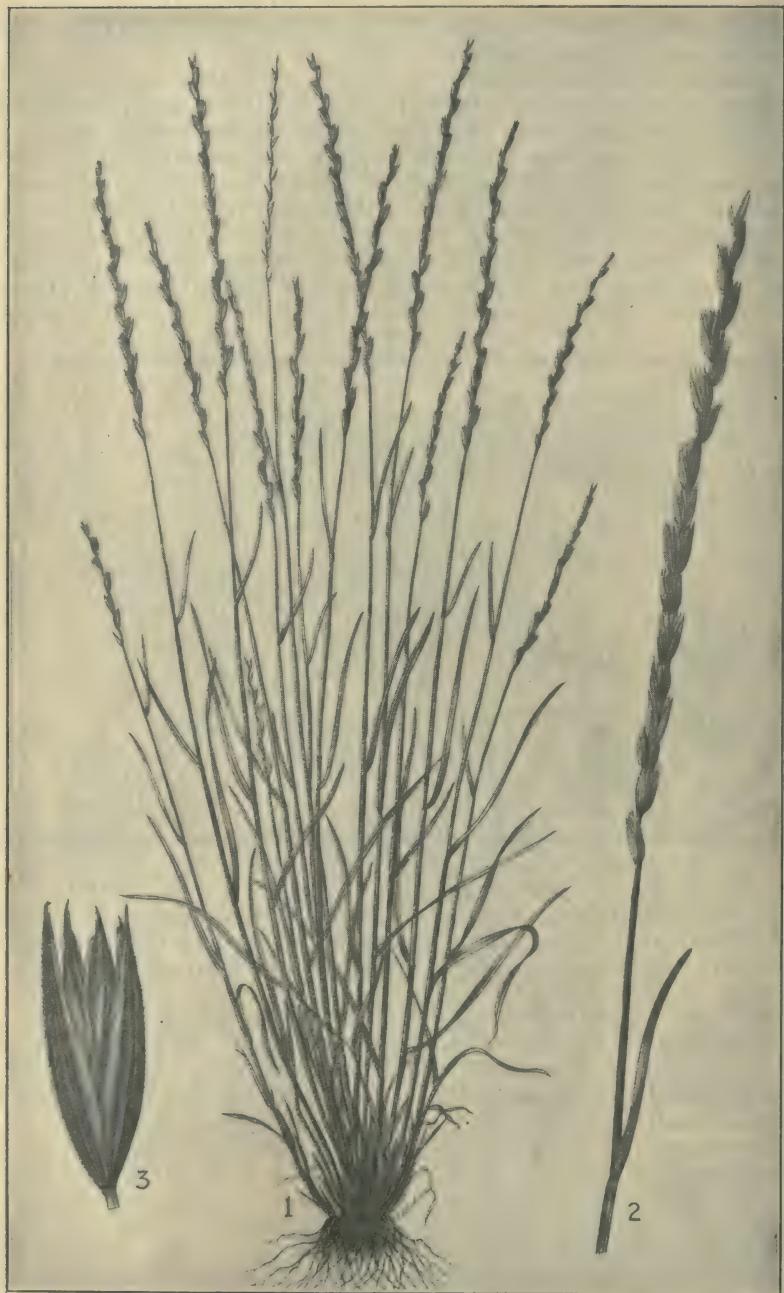


FIG. 3.—Slender wheatgrass (*Agropyron tenerum* Vasey): 1, Plant showing habit (about one-fourth natural size); 2, a single spike (somewhat enlarged); 3, spikelet (much enlarged)

SLENDER WHEATGRASS

Slender wheatgrass (*Agropyron tenerum* Vasey; fig. 3) has the distinction of being the only native American grass that has become a cultivated crop. In Canada it is called western ryegrass and Mc-Ivor's ryegrass.

This grass occurs as a native from New Mexico to Alaska and Manitoba and eastward to Pennsylvania and Newfoundland, but is most abundant in the interior regions of the West (fig. 4). It is a very variable grass in different parts of its range, and some of the forms are doubtless more valuable than others for cultivation. Slender wheatgrass grows in dense bunches or tufts, sometimes 1 foot in diameter, with numerous erect stiff flowering stems 2 to 4 feet high. The flower cluster is narrow and rather dense, 2 to 4 inches long, not unlike a head of wheat, but much more slender.

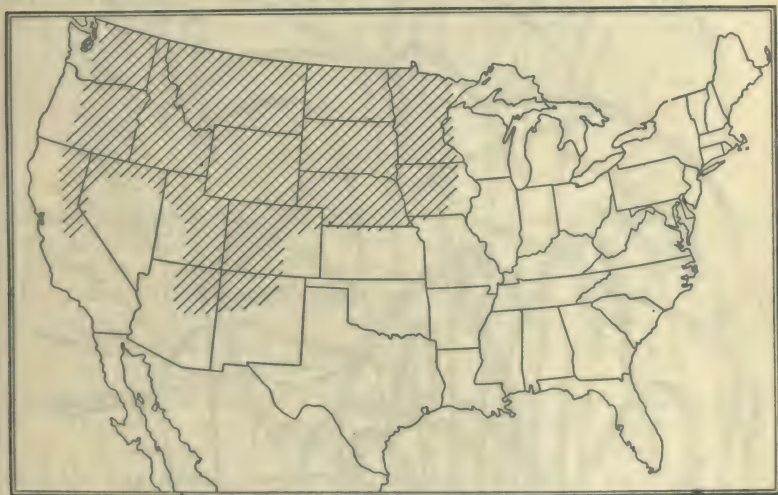


FIG. 4.—Region of the United States in which slender wheatgrass is most valuable

While typically a bunch grass, it may form rootstocks under favorable conditions. Over considerable areas it is a very valuable range grass, growing most abundantly in the alluvial lands along streams and only occasionally on the higher bench lands. It does not persist, however, on river bottoms which are occasionally flooded. It is notable for its ability to grow in alkali lands where most other grasses fail.

This grass was first cultivated about 1895 and is now grown most abundantly in Manitoba, Alberta, Saskatchewan, and the Dakotas. From the results of numerous experiments it seems to be the best perennial grass known that is adapted to dry-land conditions with the exception of Hungarian brome grass. The hay should be cut when the seeds are in the early dough stage. If the grass is allowed to become older before cutting, the hay is not so palatable. Ordinarily the yield of hay is 1½ to 2 tons per acre, but occasionally it is as high as 4 tons. Sometimes a second small cutting is obtained.



FIG. 5.—Johnson grass (*Sorghum halepense* (Linnaeus) Persoon, *Andropogon halepensis* (Linnaeus) Brotero, *Holcus halepensis* Linnaeus): 1, Plant showing habit, including creeping rootstocks (about one-sixth natural size); 2, a panicle (about natural size); 3, branch with one fertile and two sterile spikelets (somewhat enlarged); 4, fertile spikelet seen from the ventral side (much enlarged)

At Guelph, Ontario, slender wheatgrass gave the highest yields of hay of 15 grasses tested for six years. The grass is late in maturing, even later than timothy.

In Saskatchewan mixtures of slender wheatgrass with alfalfa and with red clover proved very satisfactory.

Slender wheatgrass may be sown alone, but usually succeeds well sown with a crop of wheat or oats. Different authorities have advised as low as 10 pounds and as high as 35 pounds of seed per acre. In Ontario splendid results are secured with 15 pounds sown in spring with a grain crop. In Wyoming 35 pounds per acre gave a good stand. Fall sowing in Saskatchewan at the rate of 15 pounds per acre produced a fine stand that survived the winter perfectly. It is probable that a higher rate of seeding is desirable where the conditions are not very favorable.

Seed is produced in abundance and easily harvested. Most of it is produced in Canada. There are apparently no recorded data as regards the yield of seed, which weighs about 20 pounds to the bushel.

Slender wheatgrass is very variable, the numerous forms being very different one from another. Perhaps in no other native grass is there better opportunity for selection in order to secure the best form for each section where it is adapted.

JOHNSON GRASS

Johnson grass (*Sorghum halepense* (Linnæus) Persoon, *Andropogon halepensis* (Linnæus) Brotero, *Holcus halepensis* Linnæus; fig. 5) is a native of the Mediterranean region from the Madeira Islands to Asia Minor and southeastern Europe. Closely related forms occur in India, the Malay Peninsula, and the Philippines. The grass was first described from specimens collected at the city of Aleppo, whence the specific name.

The grass was introduced from Turkey into South Carolina about 1830. The seeds were brought back by a planter whom Governor Means had sent to instruct the Turks in cotton culture, for which reason the name Means grass still is used in South Carolina. It gets its present common name from Col. William Johnson, who grew it extensively at Selma, Ala., beginning about 1840. Other common names that have been used are Aleppo grass, racehorse grass, false guinea grass, and evergreen millet.

Johnson grass is now widespread in the United States, being found across the continent northward to Virginia, Oklahoma, and northern California. Farther northward it occurs occasionally but does not persist, being destroyed in severe winters. In the West it is grown mainly in irrigated areas. In the North it can be utilized only as a summer crop, as nearly every winter the plants are killed (fig. 6).

While Johnson grass has merit as a forage plant, the difficulty of eradicating it has given the plant an unenviable reputation as a weed. It is emphatically a rich-land plant and on poor soils rarely proves objectionable as a weed. Large areas of rich land, particularly river bottoms, the black lands of Alabama and Mississippi, and the richer lands of Texas, are now heavily infested with it.

On some of these lands Johnson grass is utilized as a crop. A common practice is to grow a winter crop of oats or oats and vetch, after which two or sometimes three crops of Johnson grass can be cut for hay. The hay is considered to be of good quality, but the fear of the grass as a weed greatly limits its market.

The weedy habit of Johnson grass is due to its long underground stems, or rootstocks, which may penetrate the soil 2 or 3 feet deep. When constantly pastured or cut frequently for hay the rootstocks do not grow much and consequently are not far below the surface. In this condition it is more easily destroyed by shallow plowing followed by frequent harrowing, especially in dry hot weather. When constantly mowed or pastured Johnson grass apparently dis-



FIG. 6.—Region of the United States in which Johnson grass is perennial

appears, but if the land be plowed an abundant growth often appears from the dormant rootstocks.

Johnson grass can scarcely be said to be a cultivated grass, but many farmers prefer utilizing it as forage to fighting it as a pest. Once established it persists indefinitely, especially if the land is plowed each year. If this is not done the crops of Johnson grass become very small. Sometimes fields are plowed up in winter so that the hogs can eat the rootstocks, of which they are fond.

Some seed of Johnson grass is harvested, especially in Texas, but the demand for it is small.

Johnson grass is the most striking example in America of a plant purposely introduced which has become a pest, and it emphasizes the need of care in testing a plant thoroughly before it is distributed to farmers. Even though it possesses forage qualities of merit, Johnson grass can scarcely be considered an asset.

BIRDGRASS, OR ROUGH-STALKED MEADOW GRASS

Birdgrass (*Poa trivialis* Linnæus; fig. 7) is a native of northern Europe and one of the abundant and valued pasture grasses of



FIG. 7.—Birdgrass, or rough-stalked meadow grass (*Poa trivialis* Linnaeus): 1, Plant showing habit (about one-third natural size); 2, a panicle (about natural size); 3 and 4, spikelets (much enlarged); 5 and 6, florets showing the long tuft of hairs at the base of each lemma (much enlarged)

that region. It was early introduced into the United States, probably in mixed seeds, and now occurs generally from the Atlantic to the Pacific. It is common southward as far as Virginia and Missouri and sometimes is found in shady places farther south.

Birdgrass is best adapted to cool, moist soils. In shady places it thrives better than any other turf grass and makes exquisite lawns. During the hot weather of midsummer the grass suffers severely and apparently disappears in open places, but again grows actively with the coming of fall. In Canada and the northern tier of States it remains green all summer; farther southward it becomes dormant in midsummer except in shady places (fig. 8).

Birdgrass spreads by stolons or creeping branches on the surface of the ground. Unlike Kentucky bluegrass, a near relative, it has

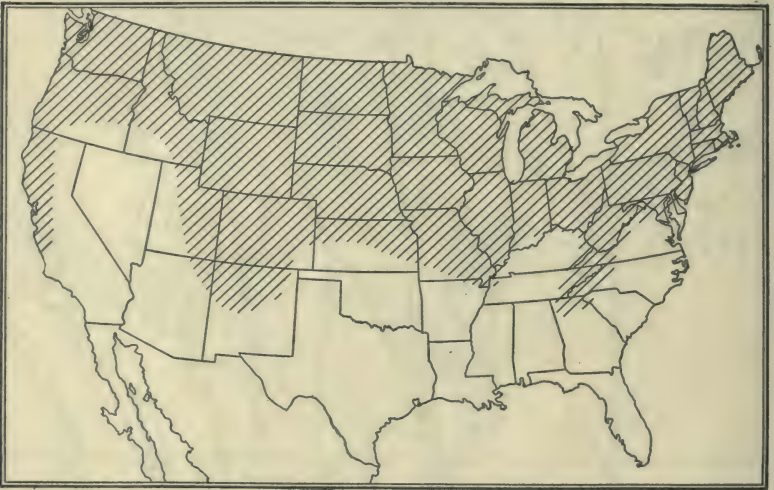


FIG. 8.—Region of the United States to which birdgrass is adapted. It does best in the northern tier of States

no underground stems. The leaves are apple-green in color, giving a very pleasing effect. Even in severe winter weather the leaves remain bright green, while Kentucky bluegrass leaves become very dull in color.

Birdgrass is a very valuable pasture grass northward, especially on moist lands. It should be much more generally used, though it seems to be spreading rapidly by purely natural means. For shady lawns it is far superior to any other grass. In Europe it has been called the "queen of the pasture grasses." The peculiar green color of northern European lawns and pastures, so different from that of Kentucky bluegrass, is largely due to the abundance of birdgrass.

Seed is produced in abundance in Europe, mostly in Denmark. One bushel weighs about 18 pounds. For use on pasture it is best combined with other grasses. On lawns it should be sown at the rate of 5 pounds to 1,000 square feet.



FIG. 9.—Creeping bent (*Agrostis stolonifera* Linnaeus): 1. Portion of a plant showing habit; note the creeping stolons which root at the nodes (about one-third natural size); 2, a spikelet (much enlarged); 3, ligule (much enlarged)

CREEPING BENT

Creeping bent (*Agrostis stolonifera* Linnaeus; fig. 9) is a valuable grass for lawns, pastures, and haymaking. Unfortunately, it became much confused with redtop and with Rhode Island bent both in botanical and in agronomic writings. From these it is easily distinguished by its dense panicle and by its creeping stolons or runners, which may grow as much as 4 feet long in a season. It is native to Europe, but perhaps the coarser seashore form known as seaside bent (*Agrostis maritima* Lamarck) is native on the Atlantic coast of America (fig. 10). This last is somewhat coarser than ordinary creeping bent, and the seeds are slightly different.

Creeping bent is most esteemed for the beautiful fine turf it produces, superior to all other temperate grasses with the exception of velvet bent. On old lawns a single plant of creeping bent often makes a circular mat 3 feet or more in diameter. If a small piece of runner 2 or 3 inches long is planted in early fall in good ground,



FIG. 10.—Region of the United States in which creeping bent will thrive. In the drier areas it needs irrigation

there will result at the end of 12 months a circular mat of grass 6 to 8 feet in diameter. This mat is composed of innumerable runners which radiate in all directions from the piece planted. These runners are composed of joints an inch or less long, each of which, if planted, will give rise to a new plant. By chopping up the runners into the joints and planting these a lawn of pure creeping bent can be established, uniform in color and texture. There are many strains of the grass, bluish to green and coarse to very fine.

Creeping bent is also valuable agriculturally. In many places it is common in pastures. On both the Atlantic and Pacific coasts large areas occur in seaside meadows which are used both for hay and pasture. Inland the grass succeeds equally well, especially if the soil is fairly moist. Over 100 years ago seaside bent was exploited in Ireland by Dr. William Richardson under the name of fiorin. In many parts of the United States the grass justifies the high praise



FIG. 11.—Proso (*Panicum miliaceum* Linnaeus): 1, Complete plant showing habit (about one-third natural size); 2, a single panicle (about natural size); 3, dorsal view of spikelet (much enlarged); 4, ventral view of spikelet (much enlarged); 5, a single grain (much enlarged)

given it by Richardson. Confusion of the grass with redtop is partly the cause of fiorin being neglected.

No commercial seed is available except the trace which occurs in that of South German mixed bent. This seed is very expensive, owing to its great demand for golf courses.

PROSO, OR BROOMCORN MILLET

Proso (*Panicum miliaceum* Linnaeus; fig. 11), also called hog millet and broomcorn millet, is a plant cultivated since prehistoric times for human food. It is the "common millet" of Europe and the milium of the ancient Romans. It is probably native to central Asia and in all likelihood was first cultivated there.

Proso is readily distinguished from the foxtail millets, as the flowers are in branching panicles and there are no awns to the



FIG. 12.—Region of the United States to which proso is best adapted

florets. There are numerous varieties, varying in the looseness or density of the panicle and in the color of the chaff and seeds. The last may be white, yellow, red, brown, or black.

Proso is still largely cultivated in Europe, especially Russia, principally for the grain to be used as food. In America it is grown mostly in the Dakotas, Montana, and adjacent Canada, partly as a grain crop, partly for hay (fig. 12). The hay is considered hardly as desirable as that of foxtail millet, being more fibrous and less leafy. The yields, too, are smaller, ranging from 1 to 1½ tons per acre.

Proso is mainly grown as a catch crop on land where other crops fail. It will mature about two weeks earlier than foxtail millet when sown at the same time. It yields fairly large seed crops, commonly 10 to 30 bushels per acre and rarely 60 bushels. The seed is mostly used as feed, but should preferably be ground. It is good feed for hogs and poultry.



FIG. 13.—Reed canary grass (*Phalaris arundinacea* Linnaeus): 1, Plant showing habit (about one-sixth natural size); 2, a panicle (slightly reduced); 3, floret (much enlarged); 4, single spikelet (much enlarged)

Proso seed well cleaned weighs 56 pounds per bushel. In sowing, from 15 to 40 pounds per acre are used.

REED CANARY GRASS

Reed canary grass (*Phalaris arundinacea* Linnæus; fig. 13) is native to the northern part of both hemispheres. It is a very variable grass usually found growing in wet places. A well-known variety is the familiar ribbon grass of the gardens. Although naturally a grass of moist or wet land, often on river or lake banks subject to periodic overflows, it succeeds splendidly on high well-drained land even in regions of rather low rainfall. In its broad relations to moisture it is not unlike redtop.

Reed canary grass is a coarse species, growing 4 to 7 feet tall, but the leafy stems are stout and never lodge. The grass tends to grow in bunches 2 or 3 feet in diameter, but it spreads underground by creep-



FIG. 14.—Region of the United States to which reed canary grass is adapted

ing branches or rootstocks. The flowers are in dense cylindric clusters 3 to 6 inches long, and the seeds shatter promptly when ripe.

The cultivation of this grass began in 1824 in England and in 1850 in Germany. Some commercial seed of European origin is on the market, but its price is high. If it were not for its poor seed habits and the consequent costliness of the seed, the grass would undoubtedly be much grown. In spite of this handicap its culture is becoming enlarged, especially in the Pacific Northwest (fig. 14).

The grass is very palatable both as hay and as pasturage. Though the hay is coarse it is eaten cleanly. Yields of 6 to 9 tons per acre are reported, but these are very exceptional. One Oregon farmer writes that a field of 6 acres supported 27 dairy cows and 2 calves from April 3 to August 4—over 4 cows to the acre. In addition to the pasturage, each cow received 8 pounds of rolled barley per day.



FIG. 15.—Canary grass (*Phalaris canariensis* Linnaeus): 1, Plant showing habit (about one-fifth natural size); 2, a spike (about natural size); 3, spikelet (much enlarged); 4, a floret (much enlarged)

It is one of the earliest grasses to begin growth in the spring and will withstand pasturing well if not too closely grazed or pastured too long continuously. Some seed is now being produced in Oregon and meets ready sale there. The seed weighs 44 to 48 pounds per bushel.

CANARY GRASS

Canary grass (*Phalaris canariensis* Linnaeus; fig. 15) is an annual native to the countries about the Mediterranean Sea. Its name doubtless comes from the fact that its seed is the favorite feed for canary birds, as the grass is probably not native on the Canary Islands.

Canary grass is cultivated much after the manner of barley, the seed being sown in the fall in regions of mild winters and in the spring farther northward. The stems are from 3 to 4½ feet tall and usually many are on a single plant. The grass is easily known by its egg-shaped head, about 1 inch long, and the green and white striped glumes.

While the grass is excellent for a hay plant, it is usually cultivated wholly for the seed. Most of the

seed is at present imported, mainly from the eastern Mediterranean countries. However, excellent crops can be produced in America. In California it has averaged 10 bushels of seed, and in Saskatchewan nearly 30 bushels have been produced per acre (fig. 16).

In growing the crop it would be safe to use exactly the same methods as used for barley. While the seed has been used for human food, its main present use is as bird seed. As a hay plant it has no apparent advantage over the small grains.

RESCUE GRASS

Rescue grass (*Bromus willdenowii* Kunth; fig. 17) is also known under various other names, including Schrader's brome grass, Schrader's grass, Australian brome, Australian oats, southern chess,

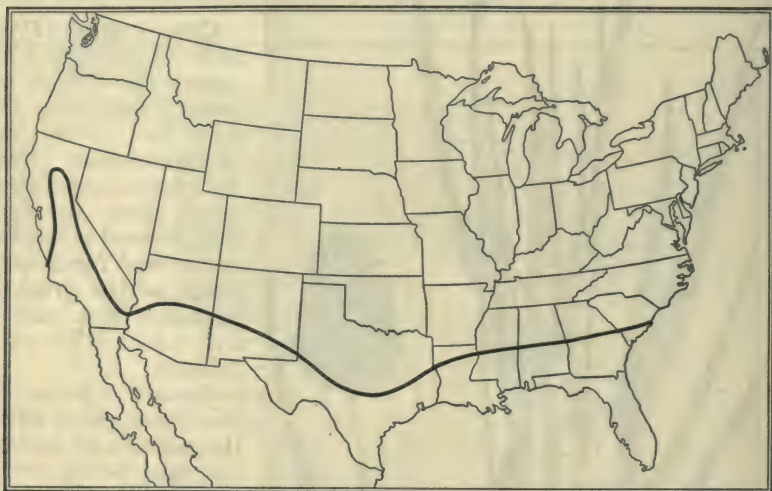


FIG. 16.—North of the line shown canary grass must be sown in the United States in the spring; south of the line in the fall

and sometimes arctic grass; in Australia prairie grass is the usual name. Another botanical name used for it is *Bromus schraderi* Kunth. It has commonly been called *Bromus unioloides*, but this name belongs to a different grass.

This grass is, with little doubt, a native of South America and is particularly abundant in Argentina and Uruguay. It was first described in 1806 from specimens sent to Berlin from Carolina. In 1853 it was advertised with high praise by B. V. Iverson, of Columbus, Ga., who gave it the name rescue grass. Since then the seed has been handled in the trade, and the grass is of some agricultural importance. In many sections of the United States, especially in the South and in the humid parts of the Pacific coast, it is naturalized. It is of increasing importance in South Africa. Agriculturally it is most important in Australia, where it is much grown and from whence comes most of the seed supply. The seed is relatively cheap and as a rule of excellent quality.



FIG. 17.—Resene grass (*Bromus willdenowii* Kunth): 1, Part of plant showing habit (about one-third natural size); 2, a single panicle (about one-half natural size); 3, spikelet (much enlarged); 4, a single floret (much enlarged)

Rescue grass is a short-lived perennial, living for four or five years under favorable conditions, but in the South behaving practically as a winter annual. It will withstand the winter as far north as Washington, D. C., and Lincoln, Nebr. Northward, however, the grass has never attained any agricultural importance (fig. 18).

This grass grows in tufts or bunches, often a foot in diameter and very leafy at the base. The stems are erect or nearly so, 2 to 4 feet high, and bear large open panicles. The large spikelets droop from the ends of long slender branches. On vigorous plants some panicles are a foot long.

Rescue grass is best adapted to humid regions with mild winters, springing up in the fall, growing through the winter, and maturing in early summer. In other words, it behaves as a winter annual in the regions where it is most valuable. It is distinctly a rich-land grass, growing vigorously on good soils but only meagerly on poor



FIG. 18.—Region of the United States in which rescue grass is most valuable

land. In view of these characteristics rescue grass has proved most valuable as a winter crop on strong soils in the South and on the Pacific coast.

The grass is sometimes cut for hay, and under favorable conditions two cuttings may be obtained. More commonly, however, it is used as pasturage, producing more than either oats or rye on good soils. It is one of the most palatable of all pasture grasses. Close grazing is not advisable, as, like nearly all bunch grasses, it is killed out by such treatment.

Rescue grass is best sown in the fall when cool weather begins. If sown alone on prepared land, from 20 to 50 pounds per acre are used. In Australia mixtures with alfalfa or red clover or Italian ryegrass are said to give excellent results. In Texas bur clover has been used mixed with rescue grass to good advantage. If the grass is allowed to mature seed late in the season and is then plowed under, a summer crop of cowpeas or Japan clover may be grown, after



FIG. 19.—Cheat (*Bromus secalinus* Linnaeus): 1. Plant showing habit (about one-fourth natural size); 2, panicle (one-half natural size); 3, spikelet (much enlarged)

which a good volunteer crop of rescue grass appears. Even on permanent pastures rescue grass volunteers well if it is allowed to mature some seed. On river-bottom lands subject to floods, rescue grass maintains itself very well.

The seeds of rescue grass are large, nearly equal to oats in size. A bushel weighs 14 to 16 pounds.

CHEAT

Cheat, or chess (*Bromus secalinus* Linnæus; fig. 19), is an annual grass native to the Old World. It often occurs in wheat fields, as the two plants behave much alike. Formerly it was believed that wheat degenerated into cheat, which gave rise to the name.

Cheat is sometimes grown as an annual hay grass sown in the fall after the manner of wheat. This culture is now much restricted, but the plant is still thus used in some southern localities under the

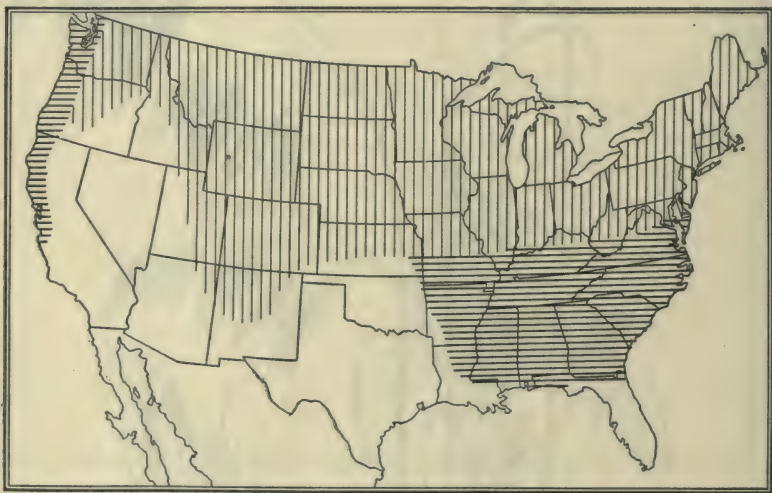


FIG. 20.—Regions of the United States to which cheat is adapted when spring sown (vertical shading) and when fall sown (horizontal shading)

name arctic grass. It makes hay of good quality, but it does not appear that it possesses any advantage over oats grown for hay.

It is a weedy grass in its habits and tends to grow in all sorts of waste places. On some poor lands it makes up a considerable element in hay fields. The seeds are often smutted, sometimes to a very large extent.

Some commercial seed is produced in the South (fig. 20), but elsewhere the plant is not now cultivated. Its culture is practically identical with that of fall-sown oats.

VASEY GRASS

Vasey grass (*Paspalum larranagai* Arechavaleta, *Paspalum vaseyanum* Scribner; fig. 21) is a near relative of Dallis grass (*Paspalum dilatatum*) and, like it, is a native of Argentina, Uruguay, etc. It



FIG. 21.—Vasey grass (*Paspalum larranagai* Arechavaleta, *Paspalum vaseyanum* Scribner): 1, Plant showing habit (about one-third natural size); 2 and 3, portions of branches, back and front view (enlarged); 4, a single spikelet, viewed from behind (much enlarged); 5, single spikelet, viewed from in front (much enlarged)

was accidentally introduced around New Orleans before 1882. The oldest specimens preserved were collected in 1882, but it was probably introduced some years before this. The grass has spread abundantly, especially on the more moist lands in Louisiana, eastern Texas, and southern Mississippi, but it occurs more or less now in the Coastal Plain region from North Carolina to Texas; also in California. It does not survive the winter at Washington, D. C. (fig. 22).

Vasey grass is an erect perennial, growing in tufts or bunches about a foot in diameter, with many erect leaf blades. The flowering culms are from 3 to 6 feet tall, each flower cluster bearing from 10 to 25 spikes. The flowers are very rarely attacked by the ergot so common on Dallis grass. The grass continues to produce flowering culms during a long season.

Where Vasey grass has become abundant much of it is cut for hay, and the quality of the hay is considered excellent. In pastures con-



FIG. 22.—Regions of the United States to which Vasey grass is well adapted

tinuous heavy pasturing must be avoided, as, like most of the bunch grasses, Vasey grass is killed out by such treatment. Vasey grass continues to grow all winter except in very cold weather and therefore affords late pasturage.

There are but scant data with regard to the time and rate of sowing Vasey grass seed. It is probable that it is best sown at corn-planting time or later. The seed is light in weight, and 10 to 20 pounds per acre should give a satisfactory stand, depending on the quality of the seeds.

Vasey grass, like Dallis grass, is remarkable for its ability to grow in wet land and also to withstand very severe drought. It thrives best on heavy soils, but succeeds well on moist sandy land. The prospects are that it will become a grass of increasing agricultural importance.

From the general way in which Vasey grass has behaved without culture, it seems highly probable that it is destined to become a



FIG. 23.—Bahla grass (*Paspalum notatum* Fluegge): 1. Part of plant showing habit (about one-third natural size); 2. portion of spike showing position of spikelets (enlarged); 3. front view of a single spikelet (much enlarged); 4. back view of a single spikelet (much enlarged); 5. front view of a single grain (much enlarged); 6. back view of a single grain (much enlarged)

cultivated grass of considerable importance in the South. Much yet remains to be learned in regard to the best methods of culture, but it is likely to be used much after the manner of timothy in rotation with other crops.

Seed is produced in abundance by Vasey grass, but on the same plant every stage from young flowers to ripe seed may be found at any time from June to November. In other words, the seed crop is never all ripe at one time. Apparently the best practice is to cut the first crop for hay and the second or last crop for seed. By this procedure more of the seed is ripe at one time. If the seed is fully ripe when harvested it germinates well, but if cut earlier it must be well cured to secure satisfactory germination. Some commercial seed is now available.



FIG. 24.—Regions of the United States to which Bahia grass is adapted

BAHIA GRASS

Bahia grass (*Paspalum notatum* Fluegge; fig. 23) is a perennial grass forming a dense sward of leaves and with flowering culms about 1 foot high, two-branched at the top. It is primarily a pasture grass. It is native from Cuba and Mexico southward to Argentina and has many local names. In western Cuba, where it is the common pasture grass, it is *cana mazo* (mat cane); in Costa Rica, *gengibrillo*; in Panama, ginger grass; in Argentina, *gramillon*, *pasto dulce*, *pasto manso*, and *gramilla blanca*. Portuguese names in Brazil and Paraguay are *graminha* and *capim de cabayu*. It is generally recognized as a very valuable pasture grass and an excellent turf former. The rootstocks are very stout, so that even on very sandy soil the grass makes a firm sod.

Bahia grass has proved hardy throughout Florida and as far north as McNeill, Miss. (fig. 24). It succeeds on nearly all types of soil, even on the sand hills, but does best in fairly firm soils.

The grass can easily be propagated by division, and it produces seed abundantly throughout the warm season. Unfortunately, the seed

for some obscure reason does not germinate well. This has proved true of seed from Cuba, from Florida, and from Costa Rica. Even when the seeds are decorticated or treated with sulphuric acid the germination is still low, usually below 10 per cent. This difficulty with the seed is the principal impediment to the extensive culture of Bahia grass at present.

At the Florida Agricultural Experiment Station, Bahia grass is spreading year by year in spite of the apparently poor seed, even into land already occupied by other grasses. A firm seed bed seems desirable. In Florida the best germination has been secured by sowing the seed in the latter part of May and in June.

The ergot which attacks Dallis grass and many other species of *Paspalum* also affects Bahia grass. Indeed, in parts of Argentina where the pastures are largely of this grass the ergot causes a disease of cattle apparently the same as that caused by the same ergot on Dallis grass in Mississippi. It is not likely, however, that this ergot will ever be serious except perhaps in limited areas where Bahia grass or Dallis grass makes up the whole pasturage.

From the results already secured it seems safe to prophesy that in time Bahia grass will occupy much of the area to which it is adapted and become a pasture plant of very high value.

MOLASSES GRASS

Molasses grass (*Melinis minutiflora* Beauvois; fig. 25) is also called gordura grass, stinkgrass, honey grass, and Efwatakala grass. The Brazilian names for it are *capim mellado* (honey grass), *capim gordura* (fatgrass), and *catinguero* (stinkgrass). Two varieties are distinguished in Brazil, *catinguero roxo* with reddish flowers and *catinguero blanco* with pale flowers. The former is more common and more vigorous.

It is native to tropical Africa south of the Sahara, Madagascar, Ascension Islands, and perhaps to Brazil, where it is abundant. The species is now cultivated in Australia, Hawaii, the Philippines, South Africa, West Indies, and the United States (fig. 26).

It is a perennial, attaining a height of 3 to 4 feet. It is highly nutritious and the most esteemed of the pasture grasses of central Brazil, where it grows upon the hills and dry lands. The whole herbage is covered with hairs which secrete a sweet sticky substance with an odor like molasses. It is reputed that molasses-grass areas are free from mosquitoes, tsetse flies, ticks, and snakes, as they become repelled or killed by the sticky substance. Allowance should be made here for exaggeration.

Seed was first received by the United States Department of Agriculture in 1899, having been sent from Pernambuco by I. Nery da Fonseca. Distribution of the seed was made and results proved its adaptability to southern conditions, especially to Florida, where it thrives splendidly. It grows strong and rapidly covers the ground and is a summer pasturage. It does not flower until the end of May, and this late-maturing habit seems to indicate that it is a promising hay grass for late cuttings. It sets seed well and volunteers freely in the southern half of Florida. Because of the peculiar odor of the grass cattle at first avoid it, but soon acquire a taste for it and then graze it eagerly.



FIG. 25.—Molasses grass (*Melinis minutiflora* Beauvois): 1, Portion of a plant showing habit (about one-fourth natural size); 2, a single panicle (somewhat reduced); 3, spikelet (enlarged)

Molasses grass is used both for pasture and for hay in Brazil. It is said to be best cut just before it blooms, as the numerous small awns on the florets are disliked by cattle. The grass is also valuable in most tropical regions where it is introduced. In Florida on high sandy land 1 acre of molasses grass gave abundant pasturage for a cow and calf for the growing season. In Rhodesia $3\frac{1}{2}$ tons of hay per acre are recorded, and in Australia even higher yields.

At the present time the commercial seed supply all comes from Brazil. The seeds are very small and the weight per bushel light.

GUINEA GRASS

Guinea grass (*Panicum maximum* Linnæus; fig. 27) is perhaps the most famous of all tropical grasses. It is native to Africa, but early was introduced into the West Indies incidental to the slave trade.



FIG. 26.—Regions of the United States where molasses grass thrives

In Jamaica it was introduced as early as 1756 and even then called guinea grass. It now occurs generally in the Tropics and Sub-tropics. In the United States it is adapted only to a narrow strip from Florida to southern California (fig. 28).

Guinea grass thrives well only on heavy, usually rich soil. In Florida it has never become of much value on the sandy soils. In the West Indies and Central America it now occupies large areas. This is mostly on land that tends to grow up into brush and then forest. To keep the land in grass it is necessary to cut the brush every year or two and then burn in the dry season. This keeps down the brush and does not injure the grass.

Guinea grass is a long-lived perennial spreading by short underground branches. Single tufts are often 4 feet in diameter and 6 to 10 feet tall. The culms are stiff and erect, leafy for half the height. The panicles are broadly pyramidal, loose, and a foot or more long. The seed shatters rather promptly when ripe.



FIG. 27.—Guinea grass (*Panicum maximum* Linnæus): 1, Plant showing habit (about one-eighth natural size); 2, a single panicle (about one-half natural size); 3, 4, and 5, different views of a spikelet (much enlarged)

There are numerous forms of guinea grass, varying in breadth of leaves, height, hairiness, etc. An important variety is the buffalo grass of South Africa (*Panicum maximum* var. *hirsutissimum*), quite hairy and with the lower branches lying on the ground and rooting at the nodes.

In the Tropics guinea grass is used mainly for pasture, but much is cut to be fed green. Six to eight cuttings can be made in a season if there is enough moisture. The grass has been used as hay and is eaten well even if coarse.

Some seed of guinea grass is harvested in Cuba. There is little demand for it, however, as where well adapted the grass spreads rapidly and continually reseeds new land. In the South it is an excellent grass to grow in 6-foot rows to use as a soiling crop.



FIG. 28.—Regions of the United States to which guinea grass is adapted

However, Napier grass, Japanese cane, and Guatemala grass are even more valuable.

NATAL GRASS

Natal grass (*Tricholaena rosea* Nees; fig. 29) is native to much of South Africa. Owing to its beauty it was first cultivated as an ornamental and thus grown in the United States as early as 1866. The beautiful rosy panicles make Natal grass highly attractive. It became accidentally introduced about 1875 at Reddick, Fla., and by 1884 had spread over large areas about that town. It is now abundant over the southern half of Florida, especially in well-drained sandy lands (fig. 30). The extreme beauty of the fields in bloom impresses every tourist, and perhaps no other experience creates so vivid a remembrance.

About 1910 Natal grass was much advertised as a hay grass for Florida, and many large fields were established. From then it spread rapidly, so that at the present time it is the principal grass



FIG. 29.—Natal grass (*Tricholaena rosea* Nees): 1, Plant showing habit (one-sixth natural size); 2, a panicle (about one-third natural size); 3, spikelet (about natural size)

over large areas of uncultivated land and practically the only herbaceous plant in citrus groves.

Natal grass is a perennial, but where the winter temperature falls to about 18° F. the plants are killed; an abundant new crop comes from the scattered seeds. The grass is remarkable for its ability to grow well on high, dry sand hills.

Under favorable conditions three crops of hay can be cut in a season, but the grass is light in weight, so that the total yield is rarely as much as 2 tons per acre. It is best to cut in early bloom when the flowers are of a bright-rose color. After these begin to fade the quality of the hay deteriorates.

Once established Natal grass perpetuates itself indefinitely. Perhaps the best method of culture is in rotation with a winter crop, and after this is harvested the grass volunteers abundantly.

Except as a purely summer crop, Natal grass is well adapted only to Florida, southern Texas, a narrow strip along the Gulf coast, and southern California. It now occurs generally in all tropical and subtropical regions, but its special value is on poor, sandy soils.

A single plant of Natal grass may form a tuft 2 to 3 feet in diameter with flowering culms 2 to 4 feet high. The outer culms soon become decumbent at the base, while the central ones are erect or nearly erect. The culms branch at the base, so that new ones constantly appear. Owing partly to this character Natal grass is an everbloomer; that is, it produces flowers from late spring until killed by frost.

The rosy panicles resemble in shape and size those of oats. They are of a beautiful rosy color, for which reason the grass has also been called Australian redtop and Hawaiian redtop. There are several varieties, one of which has very pale, nearly white, flowers.

Besides its use as a hay crop Natal grass furnishes good pasturage, and cattle eat it readily, especially if kept closely grazed. It is sometimes objected to in citrus groves, because it increases the cultivation necessary and in dry seasons consumes much of the soil moisture. However, it is certainly better than the sand spurs and Spanish



FIG. 30.—Regions of the United States where Natal grass will thrive

needles which formerly covered the ground even in citrus groves. In the pineapple district Natal grass has acquired a special value. After some years pineapple plants become badly injured by root nematodes. If the land is then put into Natal grass for a time the nematodes are destroyed, because they can not live on the grass roots. The field can then again be planted to pineapples.

Natal grass seed is produced in Australia and Florida. A bushel weighs about 7 pounds. In sowing on new land 8 to 10 pounds per acre will give a good stand, but if less is used the grass will in a short time occupy the land by the seed produced.

TEOSINTE

Teosinte (*Euchlaena mexicana* Schrader, *E. luxurians* Durieu and Ascherson; fig. 31) is a coarse annual grass, growing 6 to 12 feet



FIG. 21.—Teosinte (*Euchlaena mexicana* Schrader, *E. luxurians* Durieu and Ascherson): 1. Plant showing habit (about one-twelfth natural size); 2. a branch showing the staminate panicle at the tip and the pistillate or fertile ear in the axil of each upper leaf; 3. an ear (slightly enlarged); 4. four grains each with its long feathery stigma (enlarged); 5 and 6, different views of the mature grain.

high, usually producing many stems to each plant. It is a native of tropical America and probably of ancient cultivation. It is the nearest existing relative of Indian corn, with which it readily produces hybrids.

Teosinte was at one time extravagantly advertised as a producer of enormous crops of fodder. Under favorable circumstances, such as rich soil, ample moisture, and a long hot season, very large yields have been secured, namely, 20 to 50 tons of green forage per acre. In spite of its large yields under favorable conditions, teosinte has never become of much importance in any country. On medium and poor soils better results are secured with other coarse grasses, such as sorghum, Japanese sugar cane, and Napier grass.

Teosinte is cultivated much after the manner of corn, but the plants tiller abundantly, so the hills are planted 4 to 5 feet apart each way or in rows 5 feet apart with plants spaced about 3 feet in the row. If allowed to mature but one crop can be cut in a season, but if cut



FIG. 32.—Regions of the United States in which teosinte may be grown

when 5 feet high another cutting of the same yield may be expected.

The plant matures seed only in the extreme South. Good crops have been grown as far north as Kansas and Virginia. In Kansas the average yield for three years was nearly 24 tons per acre (fig. 32).

The crop may be utilized green, as silage, and as fodder. The fodder is rather difficult to cure. Animals readily eat the plant green or dried, but no exact feeding experiments are of record. The patent fact that teosinte has never won lasting favor with farmers can only mean that it is not as desirable as other similar crops.

VELVET GRASS

Velvet grass (*Holcus lanatus* Linnæus, *Notholcus lanatus* Nash; fig. 33) is a native of Europe early introduced into America. It now occurs over the northern half of the United States in humid regions from coast to coast. In England it is known as Yorkshire fog,



FIG. 23.—Velvet grass (*Holcus lanatus* Linnaeus, *Notholcus lanatus* Nash): 1, Plant showing habit (about one-fourth natural size); 2, a single panicle (about natural size); 3, a branch with six spikelets (much enlarged); 4, a single spikelet (much enlarged)

meadow softgrass, and by various other names; on the northern Pacific coast, where it is now very abundant, the grass is called mesquite.

Velvet grass is a hardy, long-lived, perennial bunch grass. The whole plant is pale and very hairy, and it is perhaps due to its hairiness that it is not particularly palatable to cattle. The grass possesses but little substance, so that the hay yields are much smaller than the crop would seem to promise. Under favorable conditions two cuttings may be obtained in a season. In meadows each plant tends to make a bunch a foot or so in diameter, but in pastures and lawns it spreads by short underground branches. In lawns a single plant may in time cover a space 3 feet in diameter. Correlated with this habit the grass will withstand continuous mowing or grazing. As a lawn grass it is not desirable on account of its pale color, but on the Pacific coast it always invades lawns if given a chance (fig. 34).

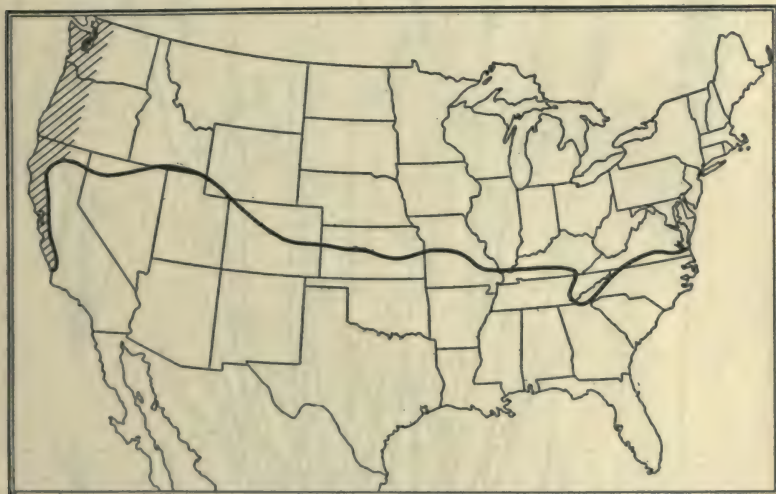


FIG. 34.—Region of the United States where velvet grass occurs (north of line shown). It is best adapted to the hatched area

Velvet grass can not be considered a first-class hay grass, but in regions where it crowds out other grasses it is perhaps better to utilize it than to attempt to kill it out. Thus, in the moist region along the Pacific coast it crowds out most other grasses, and therefore except on the better lands it is more economical to use it for hay and pasturage than to attempt to grow other grasses. It is best cut for hay when in full bloom, at which time the branches of the panicle are spreading; later they close up and become erect.

Commercial seed of velvet grass is mostly produced in Denmark and New Zealand. The latter is usually better in quality. In seeding, 20 pounds per acre is usually recommended.

When it is desirable to eradicate velvet grass, it should be cut for hay when in full bloom before the seed is developed enough to grow. Beginning about July 1, the grass should be plowed or disked shallow. During the dry weather the field requires disking frequently, so that the grass will be killed. Then the field may be seeded in early fall to whatever crop is desirable.



FIG. 35.—Sweet vernal grass (*Anthoxanthum odoratum* Linnaeus): 1, Plant showing habit (about one-third natural size); 2, a panicle (about natural size); 3, a spikelet (much enlarged); 4, a single floret (much enlarged)

SWEET VERNAL GRASS

Sweet vernal grass (*Anthoxanthum odoratum* Linnæus; fig. 35) is native to most of Europe, northern Asia, and northwest Africa. It was early introduced into America and now occurs as a naturalized grass in Canada and the United States across the continent and southward to the Cotton Belt (fig. 36). The grass is highly variable, and several of the more marked forms have received botanical names in Europe.

Sweet vernal grass receives its name partly because it blooms early and partly because the whole plant contains coumarin which gives it a vanillalike odor and a bitter taste. This is present even in seedlings, which can be recognized by their odor. Many European



Fig. 36.—Region of the United States to which sweet vernal grass is adapted.

writers have recommended that this species be included in grass mixtures to give a sweet odor to the hay. It is very doubtful, however, whether this is any real advantage.

The grass is a long-lived perennial and forms dense circular tufts. The flowering culms are erect, usually 12 to 24 inches high, but sometimes taller. It is one of the earliest grasses to appear in spring and is often abundant in pastures on poor soil. Cattle will graze on the grass but do not devour it eagerly. Its chief merits are its earliness and its ability to thrive on very poor soils. For the latter reason it is not undesirable in a mixture of other plants to form turf. It prefers well-drained soils, but will thrive in wet lands, even in peat, and apparently is indifferent to lime in the soil.

While sweet vernal grass is abundant and very well adapted to extensive regions in America, it can scarcely be called a cultivated grass. This is due to its small growth and relative unpalatability. Its greatest virtue is its ability to grow on soils where few other equally good grasses will thrive. In New Zealand, where it is very abundant, it is considered detrimental because it replaces better



FIG. 37.—Meadow foxtail (*Alopecurus pratensis* Linnæus): 1, Portion of plant showing habit (about one-fourth natural size); 2, a single spike (about natural size); 3, a spikelet (much enlarged)

grasses. In England it has been reputed to give a fine flavor to mutton, and in Norway the same is said in regard to venison.

Commercial seed comes from Europe and not infrequently has been adulterated with the annual sweet vernal grass (*Anthoxanthum puellii*). The seed is light in weight, about 10 pounds to the bushel. A pound contains on the average 924,000 seeds.

MEADOW FOXTAIL

Meadow foxtail (*Alopecurus pratensis* Linnaeus; fig. 37) is a native of the temperate parts of Europe and Asia. It has been cultivated since 1750 and is grown in Europe to a considerable extent, especially as a hay grass for rich, rather wet lands. In America it has never



FIG. 38.—Region of the United States in which meadow foxtail may be grown. It does best in the Northern States

attained any great importance, but is grown to some extent in mixtures for wet lands in the northernmost States and in eastern Canada (fig. 38).

Meadow foxtail is a long-lived perennial grass. The underground branches are short, so that the grass is in loose tufts. The flowering stems are erect and usually about 3 feet high, and the head is much like that of timothy. It begins growth very early in the spring; indeed, it is about the earliest of all cultivated grasses. Under favorable conditions two cuttings may be obtained in a season, and very rarely three. It is best cut when in full bloom. At this time the stems are very sweet, containing more sugar than most other grasses. Yields have been reported from northern Michigan and from Ontario of $1\frac{1}{2}$ tons per acre.

The grass is essentially a lover of wet land, but it does not thrive where the moisture is stagnant. On overflowed lands it succeeds well. It resists extreme winter cold, and even after growth has be-

gun in spring it endures frost well. Unlike most grasses it makes good growth in the shade.

The seed of meadow foxtail is produced in Finland, Sweden, Denmark, Holland, and New Zealand, most of the imported seed coming from the first-named country. A bushel weighs from 6 to 12 pounds. As a rule it is sown at the rate of 20 pounds per acre. A pound, depending on quality, contains from 500,000 to 1,000,000 seeds.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

November 22, 1924

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U. S. DEPARTMENT OF
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FARMERS' BULLETIN No. 1434

STANDARD BASKETS
FOR FRUITS
AND VEGETABLES



U. S. DEPARTMENT OF
AGRICULTURE
FARMERS BULLETINS 1194

STANDARDIZATION of containers for marketing fruits and vegetables is an important problem that demands the attention of the general public. It is vitally necessary in the interest of a square deal that the exact content of these packages be generally known and that the different sizes be readily distinguishable from each other.

Federal standards are now in force regarding the sizes of barrels used for fruits and vegetables and for cranberries, and Federal standards are fixed for grape baskets, berry boxes, and small till baskets.

A serious lack of uniformity is still to be corrected in the sizes of such packages as hampers, round stave baskets, splint or market baskets, and of many boxes and crates used in the marketing of perishables.

This bulletin supersedes Farmers' Bulletin 1196, Standard Containers for Fruits and Vegetables.

STANDARD BASKETS FOR FRUITS AND VEGETABLES

By F. P. DOWNING, formerly Investigator in Package Standardization, and
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CAUSES OF VARIATION IN CONTAINERS

FIFTEEN STYLES and sizes of round stave baskets, market baskets varying in size from 1 quart to 24 quarts are in common use to-day; about 40 sizes of cabbage crates, about 20 styles of celery crates, 30 lettuce crates or boxes, and 50 styles and sizes of hampers, although a relatively few standard sizes would satisfy all the demands of the trade.

Probably the most important factor contributing to the present unsatisfactory situation is the use of regional packages long established by local usage. Such packages may have been satisfactory when their use was confined to a limited territory, but of late years rapid transportation and the use of special refrigerator and ventilator cars have brought the products of every corner of this country into our great marketing centers, where the diversity of styles and sizes of containers have resulted in confusion.

The unfair competition of short-measure containers is another factor contributing to the present situation. Certain shrewd packers have found that by slight modifications in the shape of packages (fig. 1) the cubical content can be reduced substantially without noticeably affecting the appearance. Commodities sold in these containers can be offered at a lower price per package than those sold in standard packages, but the price per unit of weight is of course higher. Often this has caused the general adoption of the short-measure package, and there is no end to this procedure, for no sooner is the short-measure recognized as the standard than a still shorter one is put out by the unscrupulous minority.

The 6-quart market basket is easily confused with the peck size, the 13½ or 14 quart peach basket with the half-bushel (fig. 1), the seven-eighths bushel bean hamper with the bushel (fig. 2), and the type of 5-peck lettuce hamper shown in Figure 3 with the Florida type of 11½-bushel hamper.

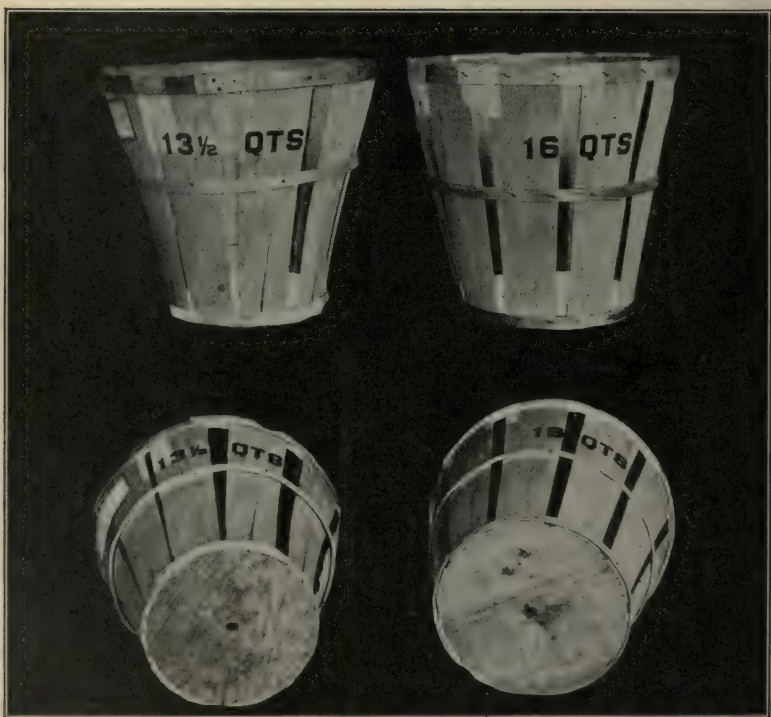


FIG. 1.—The apples on the floor represent the difference in the contents of the 14-quart and 16-quart baskets. By reducing the diameter of the bottom $\frac{1}{8}$ inch and making no change in the height of the baskets the deception is accomplished



FIG. 2.—A standard bushel hamper of 32 quarts and a seven-eighths hamper which, although shipped as a 28-quart container, held but 27 quarts. The beans in front of the short basket represent the difference in quantity held by the two baskets



FIG. 3.—Lettuce hampers vary in capacity from 40 to 48 quarts, but frequently wholesale at the same price. The smaller basket in the picture holds 37 heads of lettuce, the larger 49 heads. The difference in contents is shown on the ground

IMPORTANCE OF STANDARD CONTAINERS

Standard containers for marketing fruits and vegetables are of more interest to the average citizen than he generally realizes. He is at all times a consumer of some commodity and may be a grower or shipper of other commodities, a manufacturer of containers, or an official of a railroad, steamship line, or other carrier. As a consumer he is frequently defrauded by the substitution of short-measure packages at the full-measure price. Also the cost of marketing is increased by the greater expense of manufacturing a large number of styles and sizes and by breakage in transit, which may be due to weak packages, to improper stowage, or to the difficulty of loading odd-sized containers.

Standardization means to the manufacturer that production is simplified and that he can concentrate on a few sizes, with consequent lowering of costs. To the carrier it means the elimination of many sizes which now help to complicate the problem of damage in transit, and narrows the container problem to a few sizes for which standard strength specifications can be worked out and approved methods of stowing and bracing devised. The grower or shipper benefits by any action that lowers the cost of manufacture and tends to reduce breakage in transit. In addition standard containers provide him with a definite basis of sale so far as the size of his package is concerned. He is thus relieved of unfair competition through use by his competitor of a "short" package.

EXISTING FEDERAL STANDARDS

The Federal Government has provided by law for certain standard containers for the marketing of fruits and vegetables. They are the standard barrel, containing 7,056 cubic inches, and its subdivisions; the cranberry barrel, containing 5,826 cubic inches, with its subdivisions; three standard sizes of Climax or grape baskets, containing 2, 4, and 12 dry quarts, respectively; and standard berry boxes and till baskets, containing dry one-half pint, dry pint, dry quart, and multiples of the dry quart. The standard apple and vegetable barrel, which is ordinarily supposed to contain 3 bushels, actually holds 9 quarts in excess of that amount. In establishing this standard theoretical considerations were laid aside and the same dimensions and capacity were adopted as those of the flour barrel. The subdivisions of both barrels are three-fourths barrel, one-half barrel, and one-third barrel.

The United States standard barrel act, passed in 1915, is enforced by the Bureau of Standards, United States Department of Commerce, and in those States which have legally adopted the Federal standard by the local sealers of weights and measures. The United States standard container act of 1916, fixing standards for Climax baskets and for berry boxes and small till baskets, is enforced by the Bureau of Agricultural Economics of the United States Department of Agriculture.

The two acts have done away with a large number of unnecessary sizes of barrels, Climax baskets, till baskets, and berry boxes, and have awakened a widespread demand for the application of the same principle to other containers (figs. 4 and 5). In baskets and berry

boxes the reductions represent the elimination of 93, 84, and 82 per cent, respectively, of the sizes formerly used. This reduction has improved marketing conditions in the produce shipped in these containers because there is now no question as to the size of the container, and it works to the benefit of growers, shippers, and consumers. To the manufacturer it has meant a reduction in the number of forms necessary to supply his customers; he can now make up stock ahead of orders; and it has extended his market, because the containers which he makes are now standard and in use the country over. Similar results can be accomplished by standardization of other containers.

The United States standard barrel act has been reenacted by at least 17 of the States and the United States standard container act by Indiana, Iowa, Kansas, Michigan, Ohio, Pennsylvania, and the District of Columbia. A list of States which have standardized various types of fruit and vegetable containers is found on page 17.

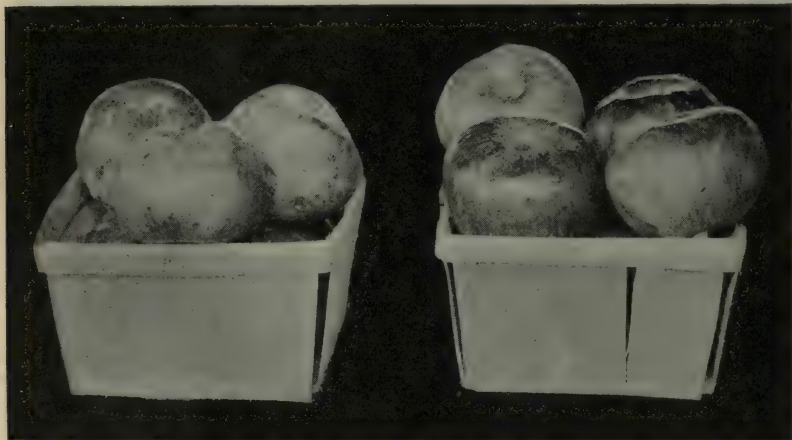


FIG. 6.—Misuse of a basket. Quart berry boxes are intended only for the marketing of berries, cherries, and similar fruits. There is a variation of 14 per cent in the weight of the apples in these baskets.

NEED FOR A FIXED UNIT AS BASIS FOR STANDARDS

The dry quart with its subdivisions and multiples is a satisfactory basis for standardizing such small containers as the berry box and small till basket; but for larger packages a larger unit must be adopted, so that the customer can recognize readily the various sizes. Most of the larger baskets now used are supposed to be based in capacity on the bushel and its subdivisions and multiples. However, there is some confusion as to what constitutes a bushel, as evidenced by the terms "struck bushel," "heaped bushel," and "weight bushel." The last two are purely arbitrary standards, varying in different localities, and the use of standards of this type is one of the causes of the present unsatisfactory conditions. The term "struck bushel" is usually understood to mean the struck United States standard bushel, commonly known as the Winchester bushel. This unit, containing 2,150.42 cubic inches, is believed to afford the most satisfactory basis for standardization.

A standard unit of measure should be permanent, definite, and of fixed and uniform value. The heaped bushel, which is in common use, is far from being fixed, and in many instances the heap has practically disappeared. A proper heap has never been defined by Congress, and in those States where an attempt has been made to describe the manner in which the measure should be heaped the phraseology generally is vague and indefinite. The heap has been referred to as a cone, the base being the top of the measure, and the height depending on the nature of the article when piled "as high as may be without special effort or design." Under this definition such vegetables as sweet potatoes might be piled so high that the heap would be as large as the measure itself. In certain States, where determined efforts have been made to secure a proper heap to the measure, dealers have provided themselves with measures of small diameter. (See fig. 7.) Obviously the smaller the diameter of the measure the smaller the heap. In shipping packages with covers the heap must necessarily be eliminated. The State of New

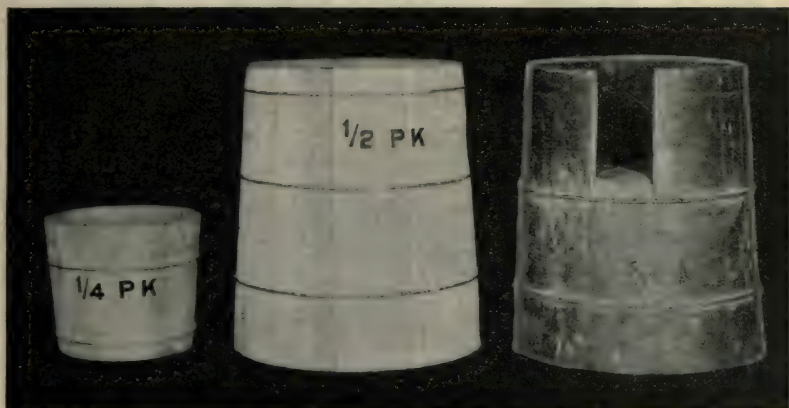


FIG. 7.—The double-ended measure, being narrower at the top than at the bottom, is easily "stacked." Its use is forbidden by law in many States

York has recognized these objections by repealing its laws requiring certain commodities to be sold by the heaped measure.

Many States have attempted to define the bushel in terms of weight. But the bushel is a unit of volume and it is impossible to define accurately a unit of volume in terms of weight, as the weight of any given volume of fruits or vegetables will vary with the size, variety, condition of the product, and the tightness of the pack.

It is not clear just what was the basis for the weight-per-bushel laws now in effect, and wide differences may be found in the laws of the various States. To illustrate, the legal weight per bushel of sweet potatoes is 46 pounds in the Dakotas and 60 pounds in Maryland; that of unshelled green peas, 28 pounds in Maine and 56 pounds in Missouri; of tomatoes, 45 pounds in Oklahoma and 60 pounds in Virginia.

If the various States were to enforce rigidly these weight-per-bushel laws, interstate commerce would be carried on under tremendous difficulties. In 1921 the State of Massachusetts appointed

a commission to investigate the expediency of revising the established legal bushel weights of fruits, vegetables, and other commodities. After a thorough investigation, including the weighing of measured bushels of many commodities, the commission reported that "the fallacy of attempting to remedy the conditions * * * by any changes in the established bushel weights is apparent, as any weight adopted must necessarily be arbitrary and can not reasonably be ex-

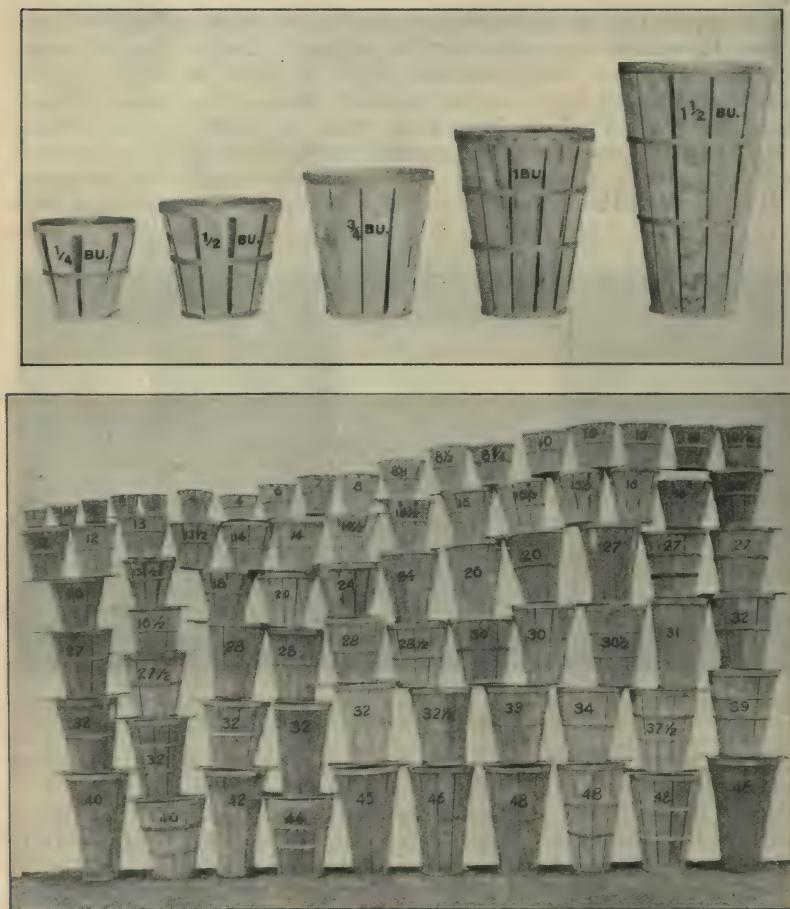


FIG. 8.—Above: Proposed standard hampers. All other styles should be eliminated. Below: Group of hampers showing sizes and styles in general use to-day. A striking illustration of the need of standardization

pected to represent the actual weight of a bushel of any commodity at time of sale." As a result of this investigation the general court of Massachusetts repealed the State's weight-per-bushel law and provided for the sale of fruits, nuts, vegetables, and grain by weight or numerical count except when sold in the original standard container. It is hoped that this action by Massachusetts is the forerunner of similar action by other States.

The most satisfactory basic unit for a system of standard containers is the struck Winchester bushel of 2,150.42 cubic inches. It is recognized indirectly as the United States standard bushel through a resolution of Congress passed and approved in 1836, authorizing the Secretary of the Treasury to prepare a set of weights for use in the customhouses and for other purposes. The Treasury Department adopted the Winchester bushel and most of the States now recognize this standard by legislative enactment. A package based upon this fixed unit of volume, when filled level with the top, is recognized easily as a full measure. Any variation or slackness in filling is detected at once even by the untrained eye.

SALES BY MEASURE VERSUS SALES BY WEIGHT

In view of the difficulties which are necessarily encountered in attempting to secure a uniform method of filling or packing standard containers, it is generally recognized that weight is the only really definite basis of sale, and for that reason the pound or hundredweight should be used where this is practicable. When products are carefully graded as to size an exception may be made, because the sales may then be made satisfactorily by numerical count.

To avoid such abuses, as frequently take place in repacking, the sale of commodities in quantities less than the original package should be by weight or numerical count. For example, 4-quart baskets of peaches are sometimes repacked so loosely that an extra basket is gained out of every five or six repacked, and 3 or 4 pounds of Malaga grapes are often removed from the California four-basket grape crate before they are displayed for sale. Another evil attendant upon repacking is the use of small containers, which, although they conform to the standards, are not suitable for measuring certain products for which they are not intended. The 1-quart berry box and 2-quart and 3-quart till baskets are used extensively by retail dealers in the sale of apples, peaches, onions, and other large fruits or vegetables. Figure 6 shows how such dealers frequently resort to deceptive methods of packing, thus defrauding the unsuspecting customer who pays well for the empty spaces in the bottom of the basket.

However, transactions involving the sale of original containers often can not be made on a net-weight basis without adding greatly to the cost of marketing. Perishable commodities must be handled with all possible dispatch, and the time and labor required to weigh each package would more than offset the good which might result from a knowledge of the exact weight. Furthermore, many sales are made while the products are in transit to market, and even if the weight at time of packing were known, a considerable variation from this weight might occur as a result of shrinkage due to drying out or decay. Then, too, a shipping package must be filled compactly without regard to weight or the product may be damaged by the movement within the container. In general it may be said that transactions involving the sale of packed fruits or vegetables in the original container should be made by the standard package; but when it is necessary to break such packages to dispose of the commodity in smaller quantities, sales should be made by weight or count.

PROPER FILLING

It is greatly to the advantage of all parties interested in marketing fruits and vegetables that, in addition to fixing standards for containers, proper methods of filling be employed. If containers are not well filled the waste space increases the package cost, and since freight charges are ordinarily based on an estimated per package weight, the carriers receive pay for more than they actually carry. (See fig. 9.) Also the product is likely to be shaken and bruised in transit and discriminated against by dealers in the markets on account of its poor appearance. The price penalty paid on account of



FIG. 9.—A "slack fill" of string beans in a short $\frac{3}{4}$ bushel bean hamper. The beans at right weigh 23 pounds, at left 25 pounds. Average weight of properly filled hampers is 27 pounds

poor filling is usually much greater than the actual weight shortage would warrant.

It is customary in packing fruits and vegetables to arrange the product to provide a bulge above the top of the container. The cover is then put in place by pressure. When the height of the pack is not excessive this is a desirable practice. As the natural shrinkage and settling occur, the product is held securely in place until the shrinkage is sufficient to offset the bulge. The extra amount of produce is more than paid for by the ready sale and better price which can always be secured for an attractive pack. However, an excessive bulge is a detriment, as it causes bruising of the product and frequently weakens the container, resulting in breakage in transit.

NEED OF FURTHER FEDERAL STANDARDS

Three important shipping containers are especially in need of standardization at the present time—the hamper, the round stave basket, and the market or splint basket. Investigations in all parts of the United States where these packages are used have shown a serious lack of uniformity in capacity, shape, and strength, which could be corrected by the adoption of standards worked out by the Bureau of Agricultural Economics.

HAMPER

The hamper is one of the most widely used shipping containers, and is especially popular in the Eastern and Southern States. Almost 30,000,000 of these baskets are used annually. When made of light materials the hamper is well adapted for marketing light produce, such as lettuce and kale; and when of heavier construction it can be used in shipping such products as sweet potatoes and apples.

A glance at Figure 8 shows a large number of styles and sizes of hampers in use at present. On account of the different shapes and

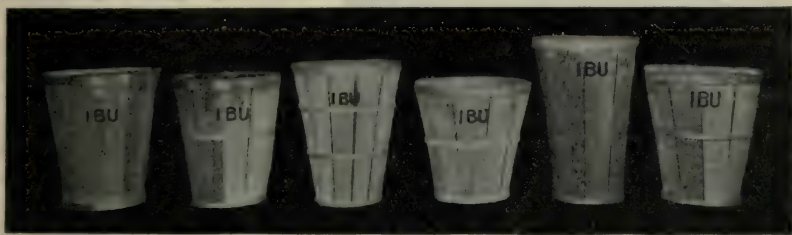


FIG. 10.—Showing need of standard dimensions for bushel hampers. The height of the six standard bushels varies from 17 inches to 22½ inches, making a carlot loading of mixed hampers difficult.

sizes it is practically impossible for a purchaser to know just how much he is getting, when he buys a hamper of produce.

The need for standard dimensions is not generally recognized. On first consideration it would seem that if all standard bushel hampers contained the same cubic content there would be no chance for deception. This is not altogether true, as will be seen by referring to Figure 10. The baskets shown in this group are all standard bushels, but one would never know it by looking at them. Another important reason for fixing standard dimensions is to facilitate the development of standard rules for loading these containers in cars.

It is estimated that one-third of the so-called half-bushel hampers which are manufactured to-day are short measure. In fact, the use of the 14-quart basket has become universal in certain districts, entirely supplanting the 16-quart or half-bushel basket.

The seven-eighth or 28-quart hamper, which is frequently so made as to hold as little as 27 quarts, is another size which should be eliminated. (See fig. 2.) It is used largely for shipping southern produce and masquerades as a full bushel in the markets. This basket has already been declared illegal in Texas, New Jersey, Indiana, Ohio, and the District of Columbia. About 25 per cent of what are commonly supposed to be bushel baskets are short measure.

Still another size in common use which should be eliminated is the 5-peck hamper. This size does not meet any need which is not filled by the 1 bushel and $1\frac{1}{2}$ bushel sizes.

The 20-quart or five-eighths bushel brace basket is used chiefly in the territory tributary to Philadelphia, where it is employed extensively in hauling tomatoes to the canneries. This size is not to be regarded as a short container, because it is more likely to be confused with the 16-quart or half-bushel basket than with a larger size; but it does not appear in the list of proposed standards recommended by the Bureau of Agricultural Economics. However, it should be noted that there is used to some extent in Philadelphia a 16-quart brace basket, which so closely resembles the 20-quart hamper in construction and size as to be readily mistaken for it.

The ordinary hamper is circular in form, but an oval shape (fig. 11) has been put on the market recently by one manufacturer. Instead

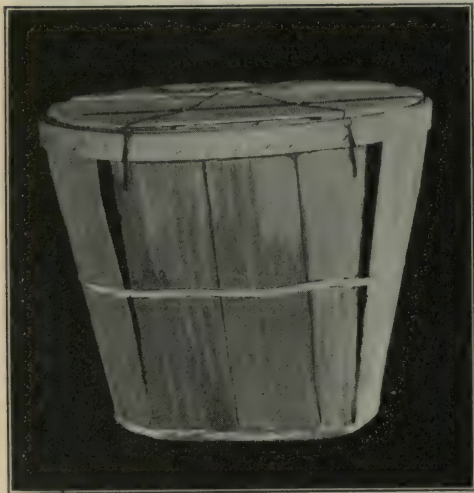


FIG. 11.—Oval hamper which has recently been put on the market

of a number of staves of equal size, this type has a wide panel on each side with three smaller staves at each end. The wide panels permit the placing of a label on the package. This hamper has been used for shipping apples, cucumbers, and sweet potatoes.

In some eastern sections a bushel hamper with a loose bottom is used for apples. The cover is placed in position, the hamper turned bottom up, and the fruit ring-packed through the bottom end. The bottom is then forced into place and nailed in.

The sizes of hampers recommended by the Bureau of Agricultural Economics

as being sufficient in number to satisfy all legitimate requirements of the trade are as follows: Eight-quart, or one-quarter bushel; 16-quart, or one-half bushel; 24-quart, or three-quarter bushel; 32-quart, or one bushel; 48 quart, or one and one-half bushel (fig. 8). All of these sizes are necessary.

The 24-quart size is recommended, because there is a demand for a container between the half-bushel and bushel sizes. This demand is now met in one section of the country by the 20-quart size and in other sections by the 28-quart size. Neither of these sizes has any place in a logical system of standard containers, whereas the use of the 24-quart size gives a series of standards of 1, 2, 3, 4, and 6 peck capacity.

ROUND STAVE BASKETS

The round stave basket is popular in all regions except the Southern and Middle Atlantic States and on the Pacific coast. It is used for shipping a large variety of fruits and vegetables and in the

field in place of the lug box. In recent years it has supplanted to some extent the 6-basket carrier in the peach districts of Georgia and the Middle Atlantic States, because of the smaller amount of labor necessary in packing. It has also become a competitor of the barrel in the packaging of New York apples. Some 18,000,000 or 20,000,000 round stave baskets are manufactured annually.

Figure 12 shows that in the case of the round stave basket a large number of unnecessary sizes are being manufactured. The sizes recommended as standard by the Bureau of Agricultural Economics are the same as those recommended for the hamper except for the addition of the 2-bushel size. These six sizes shown in the upper



FIG. 12.—Above: Proposed standard sizes of round stave baskets. Below: Twenty sizes of round stave baskets in general use to-day

part of Figure 12 can be distinguished readily from each other by the eye.

A modification of this type has been introduced recently. It differs from the ordinary round stave basket in having a flat bottom, which is made as a separate unit in the same manner as the cover, and fits inside the basket. In one style the bottom is stapled to the sides of the basket, thus forming an integral part of the container. In another style the bottom is removable. In packing this style, the cover is put in place and the basket turned bottom up, the fruit being packed through the bottom end, in the same manner as with the barrel. The bottom is then forced into position, being held in

place by wire hooks stapled through the bottom hoops of the basket, these hooks being bent over the hoop to which the veneer or slats forming the bottom are stapled (fig. 13).

SPLINT BASKETS

Splint or veneer baskets are better known to the public as market baskets. They are manufactured from either broad or narrow splints, and there is a wide diversity in the dimensions of the forms used by the different manufacturers. The broad-splint type is sometimes known as the solid veneer basket.

Splint baskets may be divided into three classes: Overhandle, drop-handle, and square-cornered. The overhandle has a single handle nailed to the center of each side; the drop-handle type has two handles that fold back over each end of the basket when not in use; and the square-cornered type, as the name indicates, has square instead of round corners. It is the best type of the three for shipping, because it is the strongest and loads in freight cars to better

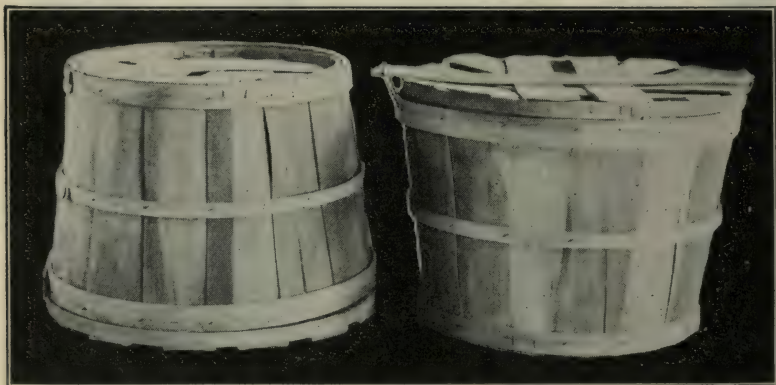


FIG. 13.—A new type of bushel round stave basket introduced in Michigan.

advantage. Square-cornered baskets are used extensively in the marketing of hothouse products, such as lettuce, tomatoes, and cucumbers.

The splint basket is used extensively as a shipping container for farm produce. In the farmers' market of one large city sales of produce in market baskets have run as high as \$11,000 in a single day, and in many other cities the market basket is one of the most common containers. It is preeminently a direct marketing package, and it is valuable because it can be carried conveniently, thus encouraging the purchase of produce in larger quantities than might be bought otherwise.

Many of the styles now in use are unnecessary and deceptive. The peck size has dwindled to one-fifth or one-sixth of a bushel, and the half bushel to 12 or 14 quarts, the standard sizes seldom appearing on the markets. The sizes which are proposed by the Bureau of Agricultural Economics are five in number: 4-quart, 8-quart, 12-quart, 16-quart, and 24-quart. Of these sizes the 12-quart and 16-quart will be used most generally. For heavy products the 12-quart

size carries better than the 16-quart. The 24-quart size is used for such products as lettuce and spinach.

The number of splint baskets used annually is not known, but more of this type are manufactured than any other. Approximately 50 per cent of these baskets are manufactured in sizes varying from 13 to 15 quarts. In Figure 14, 25 styles and sizes are shown, together with the five sizes recommended as standards.

GENERAL CONSIDERATIONS

A shipping container for fruits and vegetables should combine strength with lightness, it should be attractive, and it should provide adequate ventilation for the commodity shipped. It should be light, because no one wishes to pay more freight charges than necessary. It should be attractive, because a large part of the buying public forms its judgments through its eyes and the favorable im-



FIG. 14.—Above: Proposed sizes for standards. Below: Twenty-five styles and sizes of market or splint baskets manufactured and used to-day

pression created by an attractive package is worth considering. To insure safe arrival at market, strength, adequate ventilation, and proper stowage in the car are necessary. If arrival in good condition is overlooked, the weeks or months of work and care which have gone into the growing of the crop may amount to nothing.

The carriers of the United States say that in the handling of perishables the losses in one year amounted to \$10,000,000. Among the many causes of these losses are rough handling, failure to stow shipments properly in cars, delay in transit, lack of proper refrigeration, and frail containers. Such a tax on the fruit and vegetable business of the country calls for cooperation on the part of growers, shippers, container manufacturers, and carriers in an effort to reduce the damage to the lowest possible point.

As one step in this direction and as a protection to himself and his shipments, the intending buyer of baskets should require that the

manufacturer furnish a definite statement of the specifications on which the baskets are made. Manufacturers should be glad to supply such information and undoubtedly will do so if they are turning out a product of high quality. Many basket manufacturers are striving to put out an article which will stand up under heavy use, but there are also many baskets on the market of such poor quality that they should never be used in the shipping of fruits and vegetables.

A container for the shipment of fruits or vegetables, properly loaded and under normal traffic conditions, should be strong enough to carry the commodity intact from the grower to the wholesale market and thence to the retailer. Greater strength than this is unnecessary, but too much stress can not be laid on the importance of buyers insisting that their baskets be equal to the task imposed upon them. Although such a container will be more expensive than a lighter one, it is better to pay more than to pay less and take the risk of broken packages and lost produce.

Strength specifications apply principally to the larger baskets, which are not inclosed in crates for shipment. Strength is not so important a consideration in berry boxes and till baskets, which are placed in crates or boxes for shipment, but it is important that these small baskets should be of standard capacity.

The question of proper stowing and bracing of containers in car-load shipments of fruits or vegetables is worthy of careful thought on the part of shippers. The baskets mentioned in this bulletin have proven adapted to loading in cars. Approved methods of loading different types of packages are discussed in a series of commodity marketing bulletins that are available for distribution by the United States Department of Agriculture. Suggestions regarding proper methods can usually be obtained from railroad companies, and many experienced shippers doubtless have worked out satisfactory methods for themselves. That proper loading plays its part in safe arrival is shown by the fact that some shippers obtain satisfactory results from containers with which others have trouble.

Specifications insisted upon by the buyer should touch at least three points: Capacity, material, and workmanship. In capacity, the container should be required to hold a designated number of United States standard dry quarts, struck measure. This will insure compliance with the standard container act and will guarantee fairness to all.

As regards material, all veneer used should be of smooth finish, should be solid cut, tight grained, and practically free from decay, knots, and cross grain. Baskets should have no broken or patched staves. Wooden hoops should be of elm, beech, or gum, or wood of equal strength, and should be free from knots and cross-grain material. Thickness of material will depend on the type of basket desired, the purpose for which employed, and the kind of wood used in its construction. In general, hard maple, beech, and birch may be used a little thinner than gum, but cottonwood should be heavier.

Baskets should be of good workmanship, well stapled or nailed, and free from protruding ends of hoops or staves, loose-fitting staves, and poorly-fitting covers.

**LIST OF STATES WHICH HAVE STANDARDIZED VARIOUS TYPES OF
FRUIT AND VEGETABLE CONTAINERS WITH TITLE AND ADDRESS
OF ENFORCING OFFICIAL**

California: Director of agriculture, Sacramento. Apple box; apricot, plum, and grape baskets; berry boxes, pear boxes, half pear boxes; peach, lettuce, grape and cantaloupe crates; cherry boxes and lug boxes.

Connecticut: State board of agriculture, Hartford. Apple barrel and box.

District of Columbia: Superintendent weights, measures, and markets, Washington. Apple barrel, cranberry barrel; Climax baskets; 6-basket and 4-basket carriers; berry boxes; lug boxes; hampers; round stave baskets; apple and pear boxes, and onion crates.

Florida: Any magistrate. Tomato (4-quart till) basket; 6-basket carrier and orange box. (Note: The law gives the dimensions of the tomato basket but does not prescribe its capacity.)

Idaho: Director bureau of plant industry, Boise. Apple box; prune box; lettuce crate. Recommended standards for cherry and peach boxes; and berry, cantaloupe, potato, cabbage, and watermelon crates.

Illinois: Director of trade and commerce, Springfield. Berry boxes; fruit and vegetable barrel; cranberry barrel; bushel crate for cranberries and blueberries; one-third-barrel crate, box or basket for fruits and vegetables; containers for fresh fruits and vegetables of less than 1-bushel capacity to be of the standard capacity of 1, 2, 3, 4, 5, 6, 8, 16, and 24 quarts standard dry measure.

Indiana: State commissioner of weights and measures, Indianapolis. Hampers, round stave baskets, splint or market baskets, Climax baskets, till baskets, berry boxes, apple barrel, and apple box. The law also forbids the sale of slack-filled containers.

Iowa: Secretary of agriculture, Des Moines. Berry boxes and Climax baskets.

Kansas: Secretary of State Horticultural Society, Topeka. Climax baskets; berry boxes; till baskets; apple box and barrel.

Kentucky: Commissioner of agriculture, Frankfort. Apple barrel.

Maine: Commissioner of agriculture, Augusta. Apple barrel and box; berry boxes.

Maryland: Chief inspector bureau weights and measures, room 24, City Hall, Baltimore. Berry boxes, but permits the sale of short boxes when so marked.

Massachusetts: Division of standards, department of labor and industries, State House, Boston. Apple barrel and box; cranberry barrel; cranberry crate; berry boxes; bushel and half bushel lug boxes.

Michigan: Director bureau of foods and standards, Lansing. Climax baskets for grapes and other fruits and vegetables, baskets and other containers for small fruits and vegetables and berries, and apple barrel.

Minnesota: Commissioner of weights and measures, St. Paul. Berry boxes.

Missouri: Enforcement not lodged with any particular official. Apple barrel.

Montana: Commissioner of agriculture, Helena. Apple box.

Nebraska: Secretary of agriculture, Lincoln. Berry boxes.

Nevada: Commissioner of weights and measures, Reno. Berry boxes, Climax baskets, and till baskets.

New Hampshire: Commissioner of agriculture, State House, Concord; commissioner of weights and measures, State House, Concord. Apple barrel and box; berry boxes. Bushel and half-bushel farm-produce box.

New Jersey: State superintendent weights and measures, Trenton. Barrel; cranberry box; fruit and vegetable baskets and boxes; Climax baskets.

New Mexico: Local public weighmasters. Apple box; pear box; berry boxes on the basis of liquid quart and pint. (Note: Such berry boxes are illegal for interstate shipment, since they fail to comply with the United States standard container act.)

New York: Director of bureau of weights and measures, Albany. Barrel.

North Carolina: Chief division of markets, Raleigh. Has authority to establish standard containers.

North Dakota: Deputy chief inspector weights and measures, agricultural college. Berry boxes.

Ohio: Chief division of foods, dairy, and drugs, Columbus. Climax baskets, small fruit baskets, hampers, and round stave baskets.

Oregon: State sealer of weights and measures, Salem; State board of horticulture, Salem. Apple and pear boxes; berry boxes; cranberry barrel and box.

Pennsylvania: Bureau of standards, Harrisburg; bureau of markets, Harrisburg. Climax baskets; berry boxes; 4-quart till baskets; 6-basket crate; 32-quart berry crate, fruit and vegetable barrel; cranberry barrel.

Rhode Island: State board of agriculture, 129 State House, Providence. Bushel and half bushel lug boxes.

South Carolina: Chief, division of markets, Spartanburg. Apple barrel; bushel hamper, 6-basket carrier; 32-quart berry crate; berry boxes and till baskets.

South Dakota: Commissioner of agriculture, Pierre. Fruit and vegetable barrel; berry boxes.

Tennessee: Superintendent of weights and measures, Nashville. Berry boxes; bushel crate to hold heaped bushel, 2,688 cubic inches (12 by 14 by 16 inches).

Texas: Commissioner of agriculture, Austin. Four-basket crate; 6-basket crate; folding onion crate; orange box and berry box and crate; hampers; round stave baskets; market or splint baskets; 3 and 4 quart till baskets.

Utah: Secretary, State board of agriculture, Salt Lake City. Berry boxes; apple box.

Vermont: Commissioner of agriculture, Montpelier. Apple barrel and box.

Washington: Director of agriculture, Olympia. Pear box; cantaloupe crate; apple box; peach box; prune box; berry, cherry, potato, cabbage, and watermelon crates; Washington standard cranberry barrel (one-third United States cranberry barrel).

West Virginia: Commissioner of agriculture, Charleston. Barrel.

Wisconsin: Dairy and food commissioner, Madison. Apple barrel; cranberry barrel; bushel crate, box or basket for apples, peaches, and similar fruits; bushel crate for cranberries and blueberries; berry boxes; fruit and vegetable containers of less than 1-bushel capacity to be of the standard capacity of 1, 2, 3, 4, 5, 6, 8, 16, or 24 quarts.

FEDERAL LEGISLATION

Standard barrel act.

1. Fruit and vegetable barrel.
2. Cranberry barrel.
3. Subdivisions: Three-fourths, one-half, and one-third barrel.
4. Enforced by Bureau of Standards, United States Department of Commerce, Washington, D. C.

Standard container act. Standardizes for interstate commerce:

1. Climax baskets: 2, 4, and 12 quarts, dry measure.
2. Berry boxes: One-half pint, 1 pint, and 1 quart, dry measure.
3. Till baskets and other containers for small fruits and vegetables to be of the capacity of 1 quart or multiples thereof.
4. Enforced by Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

Net weight amendment to section 8 of food and drugs act

1. Provides for a statement of the quantity of the contents, in the case of foods if in package form, in terms of weight, measure, or numerical count.
2. Enforced by the Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

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FARMERS' BULLETIN No. 1435

DISEASES OF STONE FRUITS ON THE MARKET



PEACH BROWN-ROT



THIS BULLETIN is issued to give specific information on the various diseases which occur on stone fruits during marketing.

It has become of increasing interest to growers, shippers, carriers, and receivers of stone fruits to know the names and the causes of these diseases, how they behave in transit or storage, and how they can be controlled.

This bulletin gives most attention to the market phases of the disease problem, but field phases are considered when reference to them helps to explain conditions which may arise during the marketing process.

It is based partly on publications of State and Federal investigators and partly on information gained by six years of inspection at terminal markets by the Food Products Inspection Service of the Bureau of Agricultural Economics, United States Department of Agriculture. One of the features of this service is to show on the inspection certificate the name of the disease that occurs in the car or storage lot. With the name known the principal facts regarding the disease from the market standpoint can be found in this bulletin.

DISEASES OF STONE FRUITS ON THE MARKET

By DEAN H. ROSE

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ALTERNARIA ROT OF CHERRIES

Cause.—A fungus (*Alternaria* sp.).

Fruits affected.—*Alternaria* rot occurs on both sweet and sour cherries, but has not been seen on other stone fruits.

Geographic distribution and varieties affected.—The disease has been found on sweet cherries as follows: On Bing from Yakima and Wenatchee, Wash.; on Lambert from Emmett, Idaho; on Windsor from northern Michigan. Varieties of sour cherries which sometimes show the disease are Montmorency and Early Richmond, both from southern Michigan.

Description of the disease.—The rot on the sweet cherry occurs as a firm, brown, decayed spot in the shape of a cone with its apex extending inward from the skin toward the pit. This brown mass is made up of dead tissue, interpenetrated and apparently held together by the fungous threads. It is much firmer than the surrounding healthy tissue, so that if the skin is carefully removed the affected tissue underneath can often be lifted out intact. The skin which overlies the affected area is covered with an olive-green growth of spore-bearing threads; sometimes this spore-bearing layer is hidden under a growth of threads which are white and fluffy.

The symptoms on the sour cherry are quite different. The only similarity is the olive-green layer of sporulating mycelium growing on the epidermis, and even this soon becomes soaked with juice and looks black and matted. In the early stages of the disease there is apparently so little penetration of the fungus below the epidermis that the whole surface of a cherry may be covered with the olive-green growth before the flesh is decayed near the pit. When the tissue decay does take place it is light brown and not nearly as firm as that in the sweet cherry. No fluffy growth of the fungus has been observed on sour cherries. In general, the disease on sour cherries is

characterized by a decayed epidermis covered with a black water-soaked mat of spore-bearing fungous threads. The stems of affected cherries (both sweet and sour varieties) are nearly always dead and often contain molds of various kinds, particularly those which are known to attack only dead tissue.

Nothing is known as to where *Alternaria* rot originates or how it is affected by conditions in transit. Losses caused by it are usually small, though a few carloads of sweet cherries have been seen in which the damage amounted to 25 per cent.

BACTERIAL SPOT OF PEACHES, APRICOTS, NECTARINES, AND PLUMS

Cause.—A bacterium (*Bacterium pruni*).

Fruits affected.—Bacterial spot is an orchard disease which affects fruits, twigs, and leaves of the peach, apricot, nectarine, and plum. On all of these it causes most damage by its attack on the leaves, but often blemishes the fruit so badly that the market value of the crop is greatly reduced.

Geographic distribution and varieties affected.—This disease has been reported from practically the whole of the eastern United States. It is usually more serious in southern fruit-growing sections, but is sometimes seen as far north as Nebraska, Michigan, and New York. All varieties of peaches are susceptible to its attack, though of the more important commercial varieties J. H. Hale, Elberta, Carman, Sneed, and Champion generally suffer more damage than do Hiley, Belle, Early Crawford, and Salwey. The varieties of apricots most severely affected are Royal, Sweet Russian, Peach, and Breda; of nectarines, New White, Stanwick, and Victoria. American varieties of plums are rarely attacked, while the Japanese varieties, especially Abundance and Burbank, often show serious injury.

Description of the disease.—Symptoms of the disease are about the same on all varieties of stone fruits, the chief difference being that they are more pronounced on some than on others. Spots on the leaves show first as small, nearly transparent, water-soaked areas, which later turn dark, become dry and brittle, and finally fall out, producing the shot-hole appearance, which has given rise to one of the names applied to this disease. (Fig. 1.) Spots on the twigs appear in their final stage as slightly sunken purplish black to black areas, half an inch to 2 inches in length, and extending half to two-thirds the way around the twig.

On the fruit the disease shows first as small, very slightly discolored spots, which later enlarge and grow darker. As the disease progresses affected tissues dry out and crack, the cracks becoming so marked in later stages, when they deepen and run together, that they constitute a serious blemish and sometimes render the fruit unmarketable. On peaches and nectarines, where the cracking is more severe, it is frequently followed by infection with blue-mold and other decay fungi. In the relatively few cases of the disease which have been found on the market both of these effects—cracking, with decay following—have been seen.

Control.—Field experiments in southern peach orchards indicate that the disease can be held in check there by proper pruning, cultivation, and fertilization, all of these being practices which keep the trees vigorous and healthy. Fertilization, especially with nitrate of

soda, has given better results than either pruning or cultivation practiced alone. Spraying has very little effect on the disease.¹

BLUE-MOLD ROT OF CHERRIES AND PEACHES

Cause.—A fungus (*Penicillium* sp.).

Description and fruits affected.—Blue-mold rot is rarely found on stone fruits in the orchard, but sometimes damages them severely in transit. On all of them it is characterized by the usual scanty growth of mold, white at first and turning bluish green later, which grows along the edges of cracks in the rotten spots or generally over the surface of such spots; also by a slight browning of affected tissues and by a soft, more or less watery condition, which in peaches is very much like that produced in apples. (Fig. 2.)

The rot is more common on cherries than on any other stone fruit, although it occasionally appears in rather high percentages on



FIG. 1.—Bacterial spot of peach

peaches from California and the Northwest. It is extremely rare on peaches from other sections.

The fungus is quite common in nature on dead or decaying material of various kinds, producing there immense numbers of spores—minute bodies which serve the purpose of seeds and are the chief means by which the fungus is spread. When carried by wind, insects, or other agencies, they lodge on all plant parts above ground throughout the orchard, many of them, of course, on the fruit. If conditions are favorable they may cause decay at once, though usually such conditions do not exist until the fruit is packed and on the way to market.

Spores.—With spores present on the fruit, conditions that lead to decay, either in the field or in transit, are as follows: Water on the fruit surface, without which the spores can not germinate; skin

¹ For further information on this subject, see U. S. Dept. Agr. Bul. 543, Control of Peach Bacterial Spot in Southern Orchards, by J. W. Roberts.

breaks, which furnish easy entrances for the fungous threads produced by this germination; and temperatures of 50° F. or above, without which spore germination and growth and penetration by the threads takes place very slowly, if at all. After penetration has occurred, temperature is of less significance, since the threads can then continue to grow and cause decay even though the temperature is lowered to 40° F. Growth is not entirely checked at 32° F.

Relation to orchard conditions.—In the orchard during the growing season, although temperatures are rarely unfavorable for the rot, moisture may be lacking, and skin breaks are almost sure to be absent unless the fruit is injured by insects or wind and hail. The fruit is immature and not susceptible to attack by any of the ordinary decay fungi until late in the season. For these reasons, therefore, blue-mold rot does not often occur in the orchard.

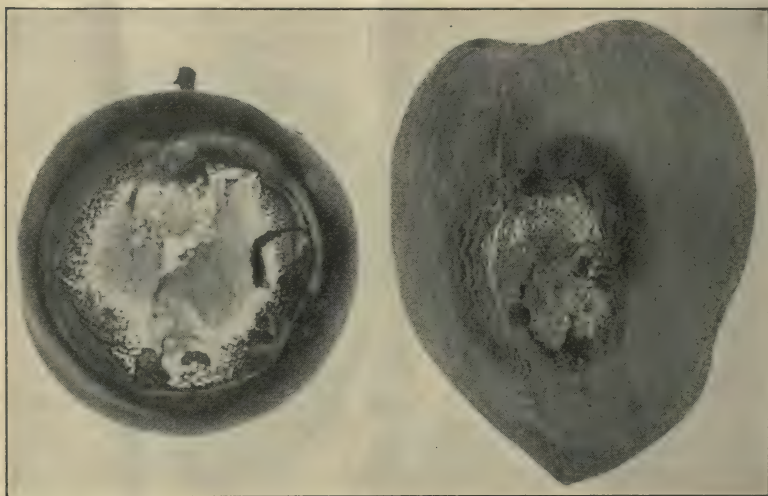


FIG. 2.—Blue-mold rot of plum and peach

Relation to conditions in transit.—Conditions in transit may be and often are distinctly favorable to the spread of the disease. Careless handling prior to loading or rough handling of the car in transit causes numerous skin breaks; rain or heavy dews at picking time or a moist atmosphere in the car causes the fruit surface to be moist when loaded or to become so soon afterward; the temperature may be high at first—above 50° F. at lowest—due to the loading of warm fruit and to delayed or inadequate icing. As a result, the few spots of decay already present develop further and new ones are started where injuries occur. Throughout the transit period temperatures considerably below 50° F.—between 40° and 45° F.—are necessary if heavy losses are to be prevented. These temperatures can be obtained only by the most careful attention to icing. The fruit can be cooled more quickly and kept cooler throughout the transit period by installing slatted false floors before loading, by stowing the load in such a way as to allow free circulation of air, and by salting the

ice. If such methods are used, it is well to install solid bulkheads to prevent freezing near the bunkers.

Even under these conditions the top of the load may be 5 to 10 degrees warmer than the bottom, a difference which is also found in cars with only the ordinary equipment. With false floors and salted ice the load cools so quickly that no part of it stays long at a temperature favorable to blue-mold rot; without them cooling goes on more slowly and the rot may get a start, not only at the top but lower down in the load, and may reach serious proportions by the time the car arrives at destination. Delay in transit increases the damage, because it gives the fungus a longer time in which to work.

Control.—Control of blue-mold rot depends on careful handling prior to loading and in transit, on prompt loading, on the proper stowing of the load, on as rapid cooling as possible to temperatures below 50° F., on the maintenance of such temperatures throughout the transit period, and on the prompt movement of the car. Whoever fails to provide his share of these conditions in the fullest measure possible is, to the extent of his failure, responsible for loss from blue-mold rot.

BROWN-ROT OF PEACHES, PLUMS, APRICOTS, AND CHERRIES

Cause.—A fungus (*Sclerotinia cinerea*).

Fruits affected.—Brown-rot is a disease primarily of stone fruits—peach, prune, plum, apricot, and cherry—although it sometimes occurs on pome fruits—apple, pear, and quince. It will be considered here only in reference to stone fruits.

Place of origin.—Brown-rot originates in the orchard, but may cause damage at any stage of the marketing process or even after the fruit reaches the consumer. In the orchard it occurs on blossoms, fruits, twigs, and limbs, the completeness of the attack depending to a considerable degree on which fruit is affected and on temperature and moisture conditions.

Spores.—The fungus which causes brown-rot winters over in diseased twigs and limbs and in dried-up rotten fruits (mummies); during wet weather in the growing season it produces, mainly on the mummies, immense numbers of spores, minute bodies which are easily distributed by wind, insects, or other agencies. The spores find lodgment everywhere, but are of greatest importance on the fruits, which are very susceptible to attack by the fungous threads produced when the spores germinate.

Spore germination.—Spore germination will not go on very rapidly unless the temperature is moderately high—50° F. or above—and there is water present on the surface with which the spores are in contact. Growth of the fungous threads is best only when the temperature is fairly high. Hence the development and spread of the disease in the orchard, particularly on the fruit, are closely associated with warm wet weather, although with high temperature a prolonged drizzly spell or a series of cloudy days with frequent showers is more dangerous than a heavy rain followed by clearing. But since summer temperatures in any peach section are usually much above the minimum required for the development of brown-rot, the chief determining factor in all sections is moisture. It thus

comes about very naturally that the rot is most prevalent and most destructive in southern peach-growing sections, considerably less so in sections farther north except during rainy weather, and almost negligible in the more arid portions of the West and Northwest.

Effect of maturity and fertilizers.—Immature fruits are rarely attacked in the field, but may sometimes suffer from the rot in transit. Ripe fruits are much more susceptible both in the field and in transit. Fruit produced on trees heavily fertilized with nitrate of soda or barnyard manure often shows increased susceptibility to the rot, especially if the application of fertilizer is made in a wet season on soil already rich. Such treatment produces peaches that are coarse in texture and sappy, a condition which seems to make the fruit open to attack by the brown-rot fungus.

Effect of skin breaks.—Breaks in the skin due to careless handling, to wind and hail, to insect injury, or to the cracking that often accompanies scab all tend greatly to increase infection (the beginning of rot at new places). In fact, without skin breaks there is little danger of infection, except under conditions of moisture and temperature which are favorable to the growth of the fungus, as, for example, in the upper layers of a carload which becomes too warm in transit (see after side heading "Control in transit") and remains so for 12 to 24 hours or more. Under such conditions the fungus is apparently able to penetrate the uninjured skin of the fruit.

Chief among insects associated with brown-rot or concerned in the distribution of brown-rot spores is the plum curculio, the eggs of which on hatching produce the worms so often found in stone fruits. When worm and rot occur in the same fruit, infection probably took place at the egg-laying puncture through spores carried either by the insect or by the wind. When the rot occurs alone, infection may have taken place at a curculio feeding puncture, or some other skin break, or directly through the otherwise sound, undamaged skin. In the Northwest, stone fruits grown west of the Cascade Mountains sometimes become infected with the rot at injuries made by the syneta leaf-beetle.

Description of the disease.—The disease on the fruit appears at first as small circular brown spots, which under conditions favorable to infection (at temperatures of 60° to 80° F.) may enlarge so rapidly as to bring about complete decay in 24 to 48 hours. The spots at no stage are sunken, and the flesh remains firm. In late stages the skin turns dark brown or even black. The fungus grows at first entirely within the fruit, but finally breaks through the skin, forming small gray spore-bearing tufts, which may be scattered here and there over the rotten spot or may become so numerous and so crowded together as to give the whole spot a grayish appearance. (Fig. 3.) The new crop of spores is able to start the disease again on other fruits. These within a few days will develop another crop that can spread the disease still further, the process being limited only by weather and the length of life of the fruit.

Geographic distribution and losses.—In the Eastern and Southern States brown-rot occurs on all stone fruits; in California chiefly on apricots; in the humid sections of Washington and Oregon on all stone fruits, though only rarely on apricots and peaches. Of 1,614

cars of peaches from 24 States examined in 1919 by Federal inspectors, 1,149 showed brown-rot to the extent of about 20 per cent, or an average for the total of about 14 per cent. The average in 615 cars from Georgia was nearly 25 per cent, in 67 from Arkansas 10 per cent, and in 41 from New York 10 per cent. The average loss in 597 cars from Georgia in 1920 was 17 per cent and in 677 cars in 1921 11 per cent.

Control in the orchard.—Brown-rot in the orchard can be controlled by a combination spray of self-boiled lime-sulphur (for the fungus) and arsenate of lead (for the curculio), though if rainy weather prevails late in the season, especially at picking time, the rot will develop and spread to some extent in spite of even the best of spraying.²

Relation to weather.—Growers and shippers find that they frequently get a different outcome for the same methods of picking and packing the same variety and what seem to be the same conditions in transit. If the identity in treatment really exists, the difference



FIG. 3.—Brown-rot of peach

in final condition is almost entirely a matter of weather at shipping point. It may occasionally be due to differences in maturity.

Effect of wet weather.—Brown-rot occurs in practically all peach orchards of the southern and eastern United States, but much more commonly in wet than in dry weather. No particular point need be made of temperature, since in the regions named, as already stated, it is rarely a limiting factor at peach-picking time. In brown-rot territory, if wet weather prevails when the crop is harvested the disease and the spores of the fungus will be abundant in the orchard. Consequently some fruits which show small rotten spots are likely to be overlooked by the packers; or fruit may be packed in which decay (infection) exists, but not at such a stage that it is visible as discolored spots; or, as a third possibility, fruit is packed on which spores

² For further information on orchard control measures, see the following publications: Farmers' Bul. 440, *Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio*, by W. M. Scott and A. L. Quaintance.

N. Y. Cornell Agr. Exp. Sta. Cir. 26, *Peach Cankers and Their Treatment*, by R. A. Jehle.

U. S. Dept. Agr. Cir. 216, *Controlling the Curculio, Brown-Rot, and Scab in the Peach Belt of Georgia*, by O. I. Snapp, W. F. Turner, and J. W. Roberts.

have lodged despite the best efforts of the grower, but have not yet caused infection. If conditions in transit are favorable for infection, the rotten spots already present (whether visible or not) will enlarge, new ones will be formed by the germination of spores lodged on the fruit, and the load will arrive at destination showing much decay.

If the weather is dry at picking time brown-rot spores will be scarce, and there will be little or no infection, either visible or invisible, on the fruit. Consequently the chances are good that very little decay will develop in transit even under conditions which might allow much of it if the fruit had been picked during wet weather. This does not mean that peaches from brown-rot territory if harvested in wet weather are bound to rot in transit under good conditions. Rather, it means that too often the conditions provided are not the best and are not really adequate to hold brown-rot in check on fruit picked in wet weather and infected with this disease.

Control in transit.—In transit there is usually moisture enough present for spore germination. Development and spread of the rot in transit therefore depend mainly on temperature. The spread of brown-rot—that is, the beginning of the rot at new places—is almost entirely prevented by temperatures below 50° F. The development of rot already present is checked somewhat at 50° and to a still greater extent the lower the temperature goes, but is able to make some progress even at 32° F. The upper limit of safety, the temperature that will prevent serious loss during the ordinary transit time, is about 45°.

Loading hot fruit and delay in transit.—If fruit is loaded hot, say, with a temperature of 80° or 90° F. (or even higher, as sometimes happens), it may take 24 to 48 hours to cool below 50° F., even though well refrigerated. Such a delay in cooling and similar delays due to belated or otherwise faulty icing of the car give time for old spots to enlarge or new ones to get started and are responsible for much of the loss brought about in refrigerator cars by this disease. Transit delays increase the loss, for by giving the brown-rot fungus a longer time in which to work they either aggravate conditions that already exist or cause others which would not have arisen if the car had moved on time.

Relation between brown-rot and car temperature.—Brown-rot is practically always worse at the top of the load than at the bottom. The temperature at the top is usually higher, often 5 to 10 degrees and occasionally 20 degrees higher. It is evident, therefore, that the higher temperature at the top causes the rot to develop more rapidly and that the lower temperature at the bottom holds the rot in check. This difference in temperature between the top and the bottom is found, however, in both well-iced and poorly iced shipments. When the difference is small it should be considered merely the result of the way in which cooling takes place in refrigerator cars. When large it may mean any one or a combination of the following: (1) A poorly constructed car, (2) a car in need of repair, (3) poor transit icing, and (4) improper stowing of the load. It occurs even when special provisions are made to hasten cooling by the use of salted ice and slatted false floors. But under such conditions the spread between the top and the bottom temperatures is

cut down, and the whole load is cooled so rapidly that no part of it remains long at a temperature favorable to the disease.

Moisture and skin breaks in transit.—Next to temperature there are two other conditions—moisture and skin breaks—that are of importance in transit. Moisture, however, is practically always present, either because of rain or heavy dew at picking time or more often as a result of condensation on the fruit due to a moist atmosphere in the car and fluctuations in car temperature. Skin breaks result from careless handling prior to loading, or in transit, or from shifting and breakage due to improper stowing of the load.²

BRUISES

Cause.—Careless handling or improper packing.

Causes and their relation to rot.—Bruising may occur on all stone fruits, but is most common on peaches. It may be caused by careless handling in picking or packing; by packing too tightly, too high, or too loosely in the package; or by rough handling in transit.

If the bruising is only moderate, it blemishes the fruit; if severe, it causes skin breaks that let in various decay organisms. Peaches in particular bruise severely and are likely to suffer skin breaks if they are packed so high in the container that force is necessary to get the cover on. The riper the peaches the greater the damage.

Not to be confused with rot.—Bruises in peaches are sometimes mistaken for rot. To distinguish the two it is only necessary to remember that in bruises the flesh has a mottled brown and white appearance and the skin is not browned, while in rotten spots both skin and flesh are brown. The shade of brown varies somewhat with the kind of rot, being considerably darker for brown-rot than for either *Rhizopus* rot or blue-mold rot.

GRAY-MOLD ROT OF PEACHES

Cause.—A fungus (*Botrytis cinerea*).

Description of the disease.—Gray-mold rot is characterized by a light-brown discoloration of the skin and underlying flesh and a rather firm texture of affected tissues. The skin around the margin of the spots slips easily under pressure from the finger, somewhat as in *Rhizopus* rot, but the decayed tissue does not have the marked sour odor characteristic of *Rhizopus* rot. Gray-mold rot has no definite odor. Rotten spots often show on the surface a scanty white to gray fungous growth, with numerous gray bunches or clumps about a third or a fourth the size of a small pinhead on short branches of this growth. These bunches are composed of spores, the minute bodies by means of which the fungus is distributed and reproduced.

As a disease of stone fruits gray-mold rot is at present known only on peaches from California. Nothing is known about how the disease originates or how it is affected by conditions in transit. It

² For further information on this subject, see the following publications:

U. S. Dept. Agr. Bull. 231, The Handling and Shipping of Fresh Cherries and Prunes from the Willamette Valley, by H. J. Ramsey.

Jour. Agr. Research, v. 22, p. 451-465, 1921, Temperature Relations of Stone-Fruit Fungi, by C. Brooks and J. S. Cooley.

In Jour. Agr. Research, v. 22, p. 467-477, 1921, Transportation Rots of Stone Fruits as Influenced by Orchard Spraying, by C. Brooks, J. S. Cooley, and D. F. Fisher.

is known, however, that the spores of gray mold are fairly common in most places where fruits are grown and that the fungus itself is able to develop and spread in transit even at the fairly low temperatures (40° to 45° F.) usually maintained in refrigerator cars. The development is slower, of course, the lower the temperature is kept. Much depends also (1) on the care with which the fruit is handled during the picking and packing process and in transit, (2) on the manner of stowing and bracing the load in the car, and (3) on whether the car is kept well iced during transit.

Losses from this disease in shipments of peaches seem to be small.

HAIL INJURY

Hail injury consists of irregular, more or less sunken spots, which often show dried-up fragments of the skin and flesh around the edges or on the surface. These spots differ from curculio injury in being larger and in showing little or no gummy exudate and no trace of larval burrows underneath. Because of the way in which they are produced, they generally occur on only one side of the fruit, whereas those due to curculios may be found on all sides. Injury by fruit beetles is sometimes mistaken for injury by hail or by curculios, but can be distinguished from either by the smooth flat layer of wound cork shown in the cavities. Damage by birds or grasshoppers occurs late in the season; hence is not likely to heal over before the fruit arrives on the market. Peaches and plums injured by hail late in the season are usually so severely damaged that they do not reach the markets.

PUSTULAR SPOT OF PEACHES

Cause.—A fungus (*Coryneum beijerinckii*).

Geographic distribution and fruits affected.—Pustular spot, also known as peach-blight, shot-hole, brown-spot, and winter blight, is a fungous disease which originates in the orchard. It occurs rather commonly on peaches in California, Colorado, and Utah, and is sometimes seen on this fruit in Michigan, Indiana, Ohio, Oregon, and New York. It attacks apricots in California, but not to any important extent elsewhere, though it has been noted on them in New York.

Description of the disease.—Spots on the fruit are at first purplish red, small, and distinct from each other. Later, as they enlarge, they show white centers surrounded by brown areas one-eighth to one-fourth of an inch in diameter (fig. 4), which by further extension may finally run together and form diseased patches covering a fourth or more of the fruit. Subsequent to this stage, cracks develop in the diseased areas and are sometimes followed by a flow of gum. Infection with brown-rot may occur at the spots, though usually the affected tissues have such a dry, corky texture that decay fungi do not readily attack them.

Relation to transit conditions.—The disease is sometimes seen on the market on peaches from California, Colorado, and Utah, and in some seasons is rather common on apricots from California. It does not spread in transit, but probably develops to some extent; that is, spots present at loading time probably enlarge slowly during

the transit period. The degree of enlargement will depend on the length of time required in transit and on the car temperature during this time. It will be less if the transit time is short and the temperature fairly low—45° to 50° F.—than if the temperature is above 50° F. and the transit time long—7 to 10 days.

Control.—Under ordinary conditions the disease can be controlled in the orchard by spraying with 5-5-50 Bordeaux mixture as soon as the leaves are off in the fall, or even before all of them are gone. When infection is common and severe, because of warm, rainy weather, it may be necessary to spray again in the spring, about a month ahead of blossoming time.⁴



FIG. 4.—Pustular spot of peach

RHIZOPUS. ROT

Cause.—A fungus (*Rhizopus nigricans*).

Description of the fungus.—The fungus *Rhizopus*, sometimes known as whiskers, has a wide distribution in nature and attacks practically all kinds of fruit, though it is not known to occur on citrus fruits and cranberries. Under ordinary conditions of moisture and temperature it is characterized by a heavy growth of long, rather coarse white threads and small spherical heads, which are white and glistening when first formed but later become black and dull; in dry, cool air only a scanty growth is produced, and the heads show as dense gray or black masses close against the fruit.

Description of the rot.—*Rhizopus* rot in peaches shows affected tissues rather light brown in color and by the time the peach is well decayed a soft condition of the flesh. At this stage the characteristic white growth and black spherical heads appear, which are easily distinguished from the grayish spore-bearing tufts of the brown-rot fungus (fig. 5). In *Rhizopus* rot the skin slips easily

⁴ For further information on this subject, see the following publications:

Calif. Agr. Exp. Sta. Bul. 191, California Peach Blight, by R. E. Smith.

Oreg. Agr. Exp. Sta. Bul. 106, Spraying for Peach Fruit Spot, by A. B. Cordley and C. C. Cate.

Oreg. Agr. Exp. Sta. Bienn. Crop Pest and Hort. Rpt., Diseases of Drupaceous Fruits, California Peach Blight and Fruit Spot, by H. S. Jackson.

Manual of Fruit Diseases, by L. R. Hepler and H. H. Whetzel.

from the diseased flesh, while in brown-rot the skin clings tightly to it.

In apricots, *Rhizopus* rot has much the same symptoms as in peaches. In plums, prunes, and cherries a soft, leaky condition appears that may or may not be accompanied by slight browning. In all of these fruits a strongly acid odor is usually noticeable when the rot becomes well advanced.

Spores.—In early stages of *Rhizopus* rot the fungus is entirely within the fruit; later on it grows to the outside, producing the coarse white growth and spherical heads already mentioned. These heads when they turn black contain minute bodies called spores, which, because of their relation to the propagation of the fungus, are of direct practical significance in the growing and handling of fruit. Being small and light, they are easily carried by the wind, by rain, by insects, and by other agencies, and are therefore common, no matter what precautions the grower may take, on the soil surface

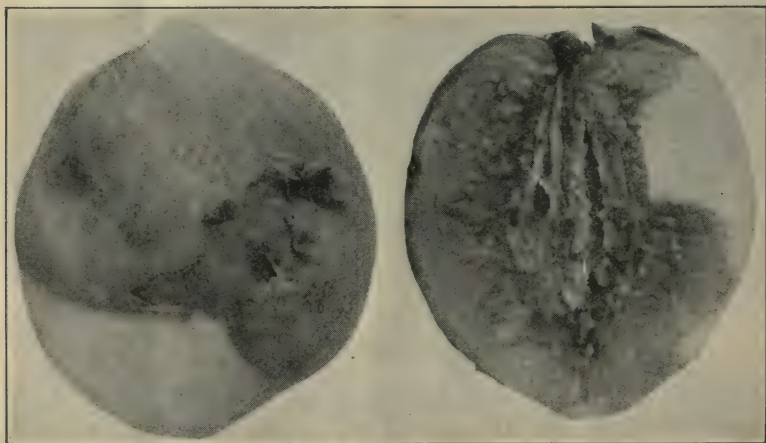


FIG. 5.—*Rhizopus* rot of peach

and on all plant parts above ground in berry fields, vineyards, and orchards. They are of most importance on the surfaces of fruits, for the reason that under favorable conditions of moisture and temperature they germinate, producing fine fungous threads which enter the fruit and cause decay. When fruits lie near each other or touch, or when they touch the ground, the rot may be spread merely by the growth of the fungous threads, though even here the original source of the threads was a spore or spores.

Mainly a transit disease.—In warm wet weather *Rhizopus* rot is occasionally found on mashed or overripe peaches and other fruits in the orchard or around the packing house, but such occurrence gives no warrant for calling the rot a field disease; it is too unusual, too much dependent on special conditions. Most of the damage from this rot takes place in transit and storage, though the occurrence of such damage is no proof that the fruit was generally diseased when it left the packing house. There may have been a few slightly rotted

fruits in the package and a few so recently or so slightly infected that they showed no discoloration or marked softening; but the more plausible assumption is that despite the best efforts of the grower the fruit bore on its surface *Rhizopus* spores, which, because of conditions in storage or in transit favorable for spore germination and for the growth of the fungous threads, started the rot at new places after the load went into the car or the storage room. Such favorable conditions would, of course, hasten the growth of the mold in fruits already attacked and promote its further spread to others lying near or touching them.

Relation to conditions in transit.—The development and spread of *Rhizopus* rot is greatly favored by water on the fruit surface and a way of entrance through the skin. Water may be present on fruit picked and loaded during times of rain or heavy dew or it may condense there because of a moist atmosphere in the storage room or car and fluctuations in the car or storage-room temperature. A way of entrance for the threads produced when spores germinate may be supplied by injuries resulting from careless handling prior to loading or in transit or from shifting and breakage due to improper stowing of the load. While there may be some danger of loss from *Rhizopus* rot when injuries are few, it can not be too often emphasized that the danger is much greater when they are many. A product which has suffered from careless handling of any sort is much more liable to attack not only in transit but after arrival on the market than one which has been carefully handled at every step.

Importance of temperature.—The danger of attack by the *Rhizopus* fungus in transit is greatly increased by the presence of skin breaks and moisture. Whether or not the attack takes place depends almost entirely on the temperature at which the fruit is held. For this rot the critical temperature or danger point is 50° F. Two or three degrees below this the product is fairly safe, provided the cooling to 50° F. or below is done as soon as possible after the fruit is loaded or stored and the temperature specified is maintained during all of the transit or storage period. Experiments with peaches conducted by the Department of Agriculture have shown that with the usual number of days in transit for most peach shipments, the *Rhizopus* fungus can produce little or no damage at 50° and none at 45° F. Whether it can make any start whatever at 45° F. seems to be determined mainly by the maturity of the fruit, since at that temperature it produces evident rot in 6 days on ripe peaches and not until the end of 12 days on green ones.

The experiments showed also that once the rot gets started it will continue to develop at a temperature (45° F.) considerably lower than that required for the beginning of rot at new places (50° F.). For this reason delay in cooling, due either to the loading of warm fruit or to failure to ice cars promptly, is always risky, as it gives opportunity for the rot to get started and so increases the probability of damage by it. By giving the fungus a longer time in which to work the delay aggravates conditions that already exist or causes others to arise which would not have arisen if the car had moved on time.

Losses.—The extent of the damage caused by this rot in transit is well shown by the Federal inspection reports. In 1919, out of 1,644

cars of peaches examined (originating in 17 States), 212 showed Rhizopus rot to the extent of about 8 per cent, or an average of 1 per cent for the whole number inspected. In general, the loss was greater in cars from the West and Northwest than in cars from the East and South, although it was sometimes considerable even in cars from the South. Cars from certain States showed losses as follows: 50 from Colorado, 8 per cent; 63 from Utah, nearly 3 per cent; 8 from California, 20 per cent; 29 from Washington, 10 per cent; and 28 from Georgia, 12 per cent.

Effect of precooling.—Precooling does much to obviate the danger of attack by Rhizopus and other fungi, as is shown by tests made in the Northwest with prunes and cherries. Cherries precooled, then held in an iced car, showed after 5 days of such storage 2.2 per cent of decay; after 10 days, 6.6 per cent; and after 15 days, 9.8 per cent. Similar lots similarly stored, but not precooled, showed at the end of 5, 10, and 15 days, respectively, 3.2, 9.2, and 13.5 per cent decay. Results equally striking, or even more so, were obtained with prunes and with both prunes and cherries in tests which compared the effect of delayed and immediate shipment and delayed and immediate precooling.⁵

RUSSET OF PLUMS AND PRUNES

Cause.—In doubt.

Symptoms and significance.—The signs of this disease are irregular, rough, russeted spots anywhere on the surface of the fruit. Nothing is known definitely as to the cause of them. They are thought to be due to the combined action of aphids, a surface-growing fungus, and weather conditions, possibly frost.

Russet is of importance merely as a blemish.

SCAB OF PEACHES

Cause.—A fungus (*Cladosporium carpophilum*).

Place of origin.—The fungous disease known as scab originates in the orchard. It makes a rather general attack there on leaves, twigs, and fruit, but is of most importance on the fruit.

Description of the disease.—On the leaves scab is characterized by brown spots in which the tissue dries up and finally drops out, leaving circular holes. It is not an important leaf disease. On the young twigs it appears as roughly circular yellowish brown blotches with a dark-gray to bluish border. The fungus here usually affects only the outer layer, but may girdle and kill the twig. It winters over on the twigs, producing the minute bodies called spores which spread the disease through the orchard.

On the fruit scab occurs as small circular spots, olive green to black in color, which affect only the skin and a shallow layer of flesh underneath. (Fig. 6.) These spots may occur anywhere on the fruit, but are usually confined to the side that is uppermost as it hangs on the tree. When infection is severe the spots coalesce to form large dark sooty areas, and the fruit becomes dwarfed or misshapen owing to the formation of a protective layer of cork under

⁵ See footnote 3 for a list of publications giving further information on this subject.

the diseased area. Cracks may be formed by the breaking of this protective layer and a way opened for infection by the brown-rot fungus, by *Rhizopus*, or by blue mold. In dry seasons the disease is very light, occurring in the form of separate spots which blemish the fruit but do not greatly affect its market value. In wet seasons it may become so serious, owing to the coalescence of the spots and subsequent cracking, that the whole crop is unmarketable.

Losses.—Of the diseases of the fruit of the peach, scab is second only to brown-rot in economic importance. In some seasons the loss for certain sections has been estimated at 10 per cent of the crop, while for the whole United States the total annual loss is often considerable. Of 1,644 cars of peaches examined in 1919 by Federal inspectors, 166 from 12 States of the East and South showed scab to the extent of about 15 per cent, or an average of about 2 per cent for the whole number of cars examined. No scab was reported in shipments from the West or Northwest or from Michigan or New York. Scab is rare in the central portion of Georgia, but quite prevalent in

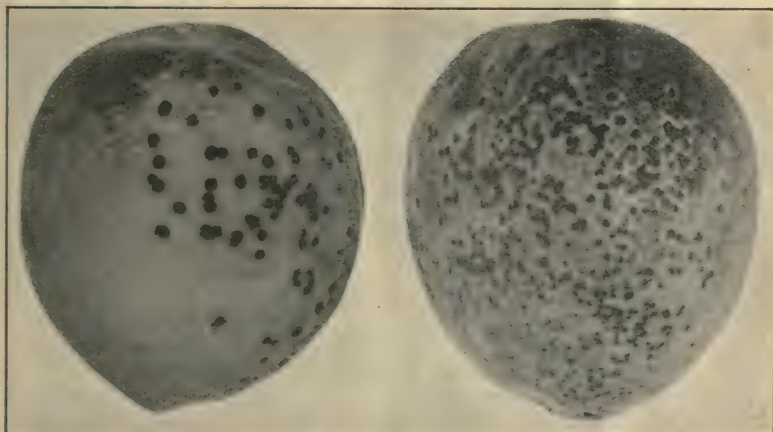


FIG. 6.—Scab of peach

the so-called mountain peach orchards of the Blue Ridge and the Allegheny Mountains.

Control.—Scab is strictly an orchard disease and does not develop or spread in transit or storage. It can be controlled by spraying with self-boiled lime-sulphur or by dusting with finely ground sulphur.^a

SPRAY INJURY

Cause.—Arsenate of lead and other sprays.

Relation to orchard conditions.—The injury appears on the side or at one end of the fruit as dry browned or blackened areas which are frequently accompanied by severe cracking of the skin and the

^a For further information on this subject, see the following publications: U. S. Dept. Agr. Bul. 395, *Peach Scab and Its Control*, by G. W. Keitt; *Farmers' Bulletin* 440.

underlying flesh. It is commonly nothing more than a severe blemish, although on account of the cracks it may open a way for the entrance of decay fungi, particularly the brown-rot fungus.

The condition here described most often is caused by the arsenate of lead solution used for the control of the curculio and is usually confined to orchards where the solution used was too strong or was applied in such a way as to drench the fruit. It may also be caused by making the application in bright sunlight during extremely hot weather.

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August 23, 1924

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1436

WHY
POTATOES
RUN OUT



MOSAIC PLANT



HEALTHY PLANT



MOSAIC, leaf-roll, spindle-tuber, and related diseases are mainly responsible for the so-called degeneration or running out of potatoes.

Reductions in yield ranging from 15 to 70 per cent or practically a total loss in severe cases may result from these maladies.

The leading commercial varieties are susceptible to one or more of these diseases, which occur in the important potato-growing sections of the United States.

Aphids, or plant lice, spread these maladies from diseased to healthy plants. Consequently, it is impossible to produce or maintain disease-free plants by growing healthy stock in fields adjacent to fields with diseased potato plants. The selection of apparently healthy hills from partly diseased stock may result in diseased progeny.

Tubers from infected plants produce diseased progeny the following season. Infected tubers can not be distinguished from healthy tubers. Therefore, it is unwise to select tubers for seed merely on account of their good appearance in the bin.

Secure practically disease-free potatoes from reliable sources for seed. Plant in fields or plats isolated as far as possible from diseased fields and not cropped with potatoes the previous season. Try to keep such potatoes free from disease by careful field inspection and by roguing frequently any abnormal plants during the growing season.

Careful field inspection of plants is more important than any single procedure for obtaining information regarding insect-borne diseases. At this time these maladies can be detected and diseased plants removed, or if high percentages of diseased plants are found the stock can be condemned for seed purposes.

WHY POTATOES RUN OUT¹

By E. S. SCHULTZ, Associate Pathologist, Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry

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INTRODUCTION

RECENT investigations of potato diseases have resulted in obtaining considerable information which will prove helpful in the improvement of this crop. The evidence at hand indicates that seed-potato improvement is very largely a matter of disease control. In Farmers' Bulletin No. 1367, "Control of Potato-Tuber Diseases," the latest observations on tuber maladies are presented. Farmers' Bulletin No. 1349, "Increasing the Potato Crop by Spraying," presents information on spraying for the improvement of the crop. In the following pages the group of so-called virus or degeneration diseases of the potato, including mosaic, leaf-roll, spindle-tuber, streak, and curly-dwarf, will be considered with respect to symptoms, dissemination, and control. Recent experimental evi-

¹ Unless otherwise indicated, the information in this bulletin is largely based upon investigations conducted as a cooperative project between the Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture, and the Department of Plant Pathology of the Maine Agricultural Experiment Station and on investigations and reports in the literature cited in the following publications. Such results of this cooperative investigation as are included herewith have already been published in different form, as follows:

Schultz, E. S., and others. Investigations on the mosaic disease of the Irish potato. *In Jour. Agr. Research*, v. 17, p. 247-274, illus. 1919.
 — and D. Folsom. Transmission of the mosaic disease of Irish potatoes. *In Jour. Agr. Research*, v. 19, p. 315-338, illus. 1920.
 — Leaf-roll, net-necrosis, and spindling-sprout of the Irish potato. *In Jour. Agr. Research*, v. 21, p. 47-80, illus. 1921.
 — Transmission, variation, and control of certain degeneration diseases of Irish potatoes. *In Jour. Agr. Research*, v. 25, p. 43-118, illus. 1923.
 — Infection and dissemination experiments with degeneration diseases of Irish potatoes. Observations in 1923. *In Jour. Agr. Research*, 1924.
 Folsom, D., and E. S. Schultz. The importance and natural spread of degeneration diseases in commercial Maine potato fields. *Maine Agr. Exp. Sta. Bul.* 316. 1924.

dence on this group of diseases shows that the so-called running out, deterioration, senility, etc., of the potato is caused very largely, if not entirely, by these virus diseases. Even though additional knowledge regarding these diseases is essential before complete control measures can be recommended, it is considered desirable to present at this time information which will be helpful in the production of better seed potatoes.

The growers of seed potatoes should know, among other things, that certain potato maladies are carried by insects, that degeneration of potatoes is largely due to these insect-borne diseases, that it is not wise to try to develop and maintain healthy stock by planting it adjacent to diseased lots, that tubers from diseased plants propagate the disease, that the selection of tubers without field inspection will not lead to the production of disease-free stock, and that cer-



FIG. 1.—Plants of the Green Mountain variety: (A) Healthy plant; (B) plant affected with mild mosaic. Mild mosaic is recognized by distinct mottling, slight dwarfing, wrinkling, and some ruffling of the leaves. Mottling is produced by more or less irregular light-green areas on the dark-green leaves.

tain practices of isolation of seed fields or plats coupled with special field inspection and the removal of diseased plants have been helpful in reducing the percentage of disease.

Since the cause of these degeneration diseases has not been demonstrated they are frequently called virus diseases, the term virus including whatever causal agents may be found later. The separate diseases have been named according to symptoms.

MOSAIC

APPEARANCE

Mosaic, so-called on account of the mottled foliage it produces, is recognized on the foliage by light-green and dark-green patches with more or less vaguely defined outlines. Three types of mosaic, mild, rugose, and leaf-rolling, have been observed on the potato.

In mild mosaic distinct mottling, slight dwarfing, wrinkling, and some ruffling of the leaves are characteristic symptoms (figs. 1 and 2).

Leaf-rolling mosaic resembles mild mosaic in slight dwarfing, slight ruffling, and wrinkling. It differs from mild mosaic in the characteristic rolling, mainly of the upper leaves, and in diffused mottling (fig. 3).



FIG. 2.—Leaf from a mosaic plant of the Green Mountain variety. Note the mottled, wrinkled, and ruffled leaflets

Rugose-mosaic symptoms are very distinct dwarfing, diffused mottling, a rugose type of wrinkling, and a tendency to show brittleness, spotting, streaking, and leaf dropping (figs. 4 and 13).

Mosaic mottling is modified by climatic conditions. In the northern seed-growing localities it is usually more distinct during the early part than the later part of the season. When seasonal condi-

tions, usually hot and more or less dry, continue during the entire growing season in these northern sections, it is very difficult to detect mosaic mottling. Under such unfavorable conditions mosaic can be recognized only in the types showing distinct dwarfing, ruffling, and wrinkling of the foliage. However, the fact that under unfavorable conditions mottling may be absent does not indicate that such plants are free from the disease, since experiments with mild-



FIG. 3.—Leaves showing leaf-rolling mosaic in the Green Mountain variety. Leaf-rolling mosaic resembles mild mosaic in slight dwarfing, slight ruffling, and wrinkling. It differs from mild mosaic in the characteristic rolling, especially of the upper leaves, and in diffused mottling.

mosaic potatoes have demonstrated that such plants or their progeny will show the mottled symptoms if again placed under conditions favorable for the development of mottling.

The most favorable environment for mosaic mottling obtains in the cooler localities of the humid regions, which are also very favorable for the best development of the potato. Under such conditions the inspection and elimination of mosaic plants can be accomplished more effectively than in the arid sections, where the mottled symptoms usually are masked. Mosaic symptoms are likewise somewhat varied on different varieties of potatoes.

OCCURRENCE AND EFFECT ON YIELD

Mosaic has been reported from all the important potato sections in this country. Different amounts of mosaic, varying from a trace to 100 per cent, have been observed in the different seed-producing localities.

Mild mosaic causes a reduction in yield frequently amounting to 15 to 30 per cent less than the product from an equal number of healthy plants (fig. 5). Plants infected with rugose mosaic or with the types of mosaic causing severe dwarfing very frequently produce only culls.



FIG. 4.—Plants of the Irish Cobbler variety: (A) Rugose mosaic plant; (B) healthy plant. Rugose mosaic is recognized by dwarfing, diffused mottling, and a rugose type of wrinkling. Such diseased plants are considerably more dwarfed than those affected with mild mosaic. Both plants show traces of Bordeaux spray

LEAF-ROLL

APPEARANCE

Leaf-roll is distinguished by the upward rolling of the leaves, so that the midrib remains at the middle of the trough thus formed. Plants becoming infected with leaf-roll while very young or plants from tubers infected with leaf-roll show rolling at first on the lower leaves, followed by rolling of progressively higher leaves until all leaves may be rolled later in the season. Plants infected late in their development may show rolling only in the upper leaves. Other symptoms of leaf-roll include dwarfing, rigidity, leathery texture, uprightness, chlorosis, yellowish, reddish, or purplish discoloration of the affected leaves, shortness of stolons, and reduction in number and size of tubers (fig. 6). A netted discoloration of the inside

tissues of the tubers called "net necrosis" is a symptom of leaf-roll in certain varieties.

The leaf-roll here described must not be confused with the rolling of the leaves produced by the following agencies and conditions: Symmetrical rolling of the leaves, due to insect injuries; rolling of the flabby and wilted leaves on plants affected with wilt; rolling of the leaves accompanied by a yellowish color on stalks showing a blackened discoloration at the base, due to black-leg; rolling of the leaves on plants subjected to excessive moisture conditions, as in localized exceptionally wet areas or during prolonged periods of rain, when practically all the plants in such areas may show rolling



FIG. 5.—Mosaic and healthy progeny from 2-stalk hills of the Green Mountain variety: (A) Progeny from mosaic hill, 1.13 pounds; (B) progeny from healthy hill, 2.13 pounds

and a more general appearance of rolling than usually obtains in true leaf-roll; and rolling of more or less flaccid leaves at the base of the stalk, due to hot dry weather.

Leaf-roll thus is easily distinguished from mosaic. Frequently, however, the two diseases are present on the same plant, resulting in more severe dwarfing than with either leaf-roll or mosaic alone.

OCCURRENCE AND EFFECT ON YIELD

Leaf-roll, like mosaic, has been reported from all the important seed-potato producing sections in this country. It has been observed in percentages ranging from a trace to more than 50 per cent. The reduction in yield caused by leaf-roll is greater than with mild mosaic. Both the number and size of tubers are reduced, so that leaf-roll hills frequently yield from 40 to 70 per cent less than healthy plants, and where net necrosis is associated with leaf-roll merely culls or no yield may result.

SPINDLE-TUBER

APPEARANCE

Spindle-tuber, so called on account of the spindle-shaped tubers produced, is commonly designated by potato growers by such terms as "running-out," "running-long," "off-shape," or "poor-shape." Additional characteristics of spindle-tuber are more or less spindling and upright stalks, somewhat smaller and slightly darker green leaves than on healthy plants, and the tubers, instead of being flat oblong, as in healthy plants, are characteristically spindle shaped or cylindrical and with more conspicuous eyes than in the normal tubers (figs. 7, 8, and 9). In the red Bliss Triumph spindle-tuber also produces a lighter red color than is found in the healthy tubers.



FIG. 6.—Leaves showing leaf-roll on the Green Mountain variety. Note the rolling of the leaves at the base of the stalks and the rigid condition of the foliage

OCCURRENCE AND EFFECT ON YIELD

Spindle-tuber occurs in the chief commercial varieties. From none to 95 per cent of spindle-tuber infection has been found in some of these varieties. The distribution of this disease is not fully known, but according to reports from some of the large seed-growing sections in this country it may be assumed that it occurs wherever the potato is grown. Reductions in yield amounting to 25 to 50 per cent may occur. In addition to reduced yields, spindle-tuber renders the shape of the tubers undesirable for first-grade marketable stock, so that it is even more detrimental to the potato industry than mild mosaic.

STREAK

APPEARANCE

Streak produces streaking, spotting, burning, brittleness, leaf dropping, and premature death, but no mottling with the exception of chlorotic spots in areas where very soon spotting and streaking

appear (fig. 10). In current-season infections these symptoms may appear only on a single shoot in a hill and sometimes apparently affecting the leaves on only one side of such shoots; later in the season other shoots in the same hill may show these symptoms. Infected stalks and petioles are exceedingly brittle, so that the leaves drop and frequently remain suspended at the base of the petiole. The tubers from plants infected early in the season remain small. Second-generation plants remain severely dwarfed, curled, and streaked and frequently die before tuber formation.

OCCURRENCE AND EFFECT ON YIELD

Streak has been observed in some of the important seed-potato growing sections. However, the percentage of diseased plants is not



FIG. 7.—Plants of the Green Mountain variety: (A) Spindle-tuber plant from a half-tuber seed piece; (B) healthy plant from a quarter-tuber seed piece. The spindle-tuber plant, from the same seed tuber as the healthy plant, became diseased in the same season as the result of grafting a spindle-tuber seed piece on a healthy tuber seed piece. Note the more spindling, upright, and slightly smaller leaf character of the spindle-tuber plant than appears in the healthy top

so large as in mosaic and leaf-roll. This no doubt is due to the fact that tubers from streak plants produce very severely dwarfed shoots, which usually die prematurely before tuber formation.

CURLY-DWARF

APPEARANCE

Curly-dwarf is characterized by very distinct dwarfing, uprightness, spindling, curling, wrinkling, some rolling, slight ruffling, brittleness, burning, and somewhat premature death of the foliage. Curly-dwarf plants produce small, spindling, gnarled, and frequently cracked tubers (fig. 11). These symptoms suggest that this disease may be the result of spindle-tuber combined with one of the mosaic types. If so, the mottling has been eliminated in the combination.

OCCURRENCE AND EFFECT ON YIELD

Since the symptoms of curly-dwarf suggest that it may be a result of spindle-tuber combined with one of the mosaic types of dis-

ease, it may appear wherever these separate diseases occur. Curly-dwarf plants usually produce small and poorly shaped tubers, suitable only for culls. Hence such plants mean practically a total loss to the grower.

COMBINATIONS OF DISEASES IN A SINGLE PLANT

Two or more of these diseases may occur on a single plant, frequently producing severe dwarfing. Such dwarfed plants have been called "mosaic-dwarf," "bad mosaic," "mottled curly-dwarf," etc. The symptoms of the single diseases usually can be recognized in these combination infections. Plants having more than a single dis-



FIG. 8.—Plants and tubers of the Spaulding No. 4 variety: (A) Healthy plant and corresponding tuber progeny; (B) spindle-tuber plant and corresponding tuber progeny. The spindle-tuber plant has more upright, more spindling shoots and smaller leaves than the healthy plant. Note that the spindle-shaped tubers have more conspicuous eyes than the healthy tubers

ease (with a few exceptions, like streak) show more severe dwarfing than those affected with one malady (figs. 12 and 13).

From the results of disease transmission by plant lice reported later it will be apparent that disease combinations may easily result in fields where more than one of these diseases occur. It is evident that continued propagation of such plants will in severe cases produce considerable reductions in yield.

WHAT CAUSES THESE DISEASES?

The cause of these diseases has not been demonstrated. It has been found that the causal substance is carried in the juice of the diseased plants. Many tests have been made by treating healthy plants with juice from diseased foliage, with the result that the plants so treated became diseased. Healthy plants have been infected by grafting diseased stalks on healthy stalks, by grafting

diseased tubers on healthy tubers, by rubbing diseased juice into the leaves of healthy plants, and by transferring or allowing plant lice to feed on healthy plants after they have fed on diseased plants.

DISEASES NOT DUE TO CULTURAL OR CLIMATIC CONDITIONS

In view of the fact that these diseases can be transmitted from diseased to healthy plants it is perfectly clear that they are not caused by poor soil conditions, by too much fertilizer, by unbalanced fertilizer, by too much rain, by dry weather, by hot weather, or

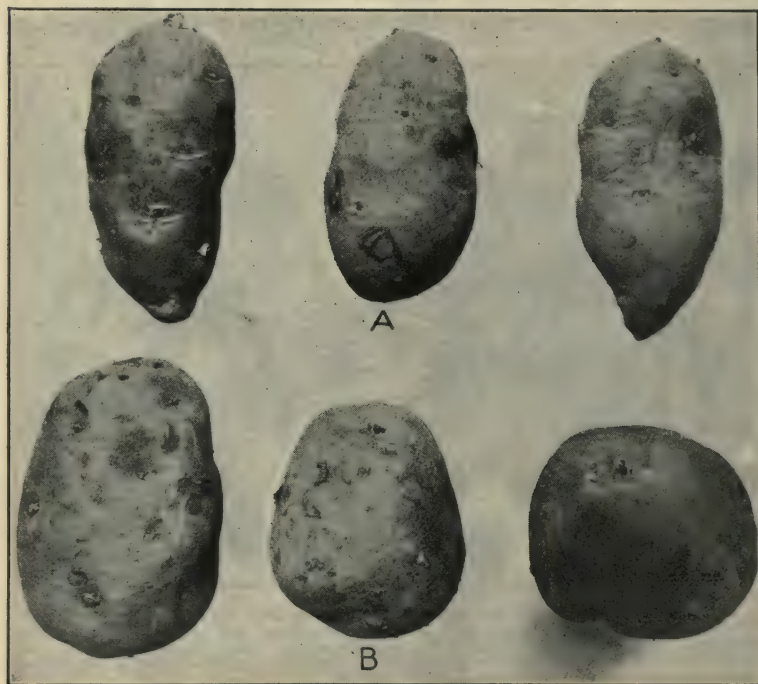


FIG. 9.—Tubers of the Green Mountain variety: (A) Spindle tubers; (B) healthy tubers

any similar condition. As has been stated previously, it is a fact that mosaic mottling may be rendered less evident during hot and dry seasons, but this is merely a response of mosaic to these conditions and not a case of cure, for such a plant still is diseased with mosaic, even if the mottling is made somewhat indistinct on account of unfavorable conditions.

Environmental factors affect the development of diseases, but such factors must not be mistaken for the cause of diseases.

SOIL DOES NOT HARBOR MOSAIC

No increase in mosaic has been found in healthy plants grown on soil on which 100 per cent of mosaic plants was grown the previous



FIG. 10.—Streak on a potato seedling. Note the dead areas, especially along the veins, producing a streaked appearance. In early stages the dead spots may be more or less circular, but become irregular in outline and spread along the veins, causing streak. Streak also occurs on stems and petioles, which in advanced stages are very brittle

season or on soil to which an extra lot of mosaic tops had been applied, as compared with the same stock of potatoes grown on soil cropped with healthy stock the previous season.

TUBERS FROM DISEASED PLANTS PRODUCE SICK PLANTS

It has been demonstrated many times that the tubers from plants affected with mosaic, leaf-roll, spindle-tuber, curly-dwarf, and streak always produce diseased plants. Tubers from apparently healthy plants grown in the same field with diseased plants may also develop diseased tops. The cause of this will be discussed under the next heading.



FIG. 11.—Curly-dwarf of the Green Mountain variety. Note the dwarfed, spindling, upright, and bushy character of the tops, with the leaves slightly rolled, ruffled, wrinkled, and curled downward at the tips

PLANT LICE, OR APHIDS, CARRY DISEASES.

Experiments have proved that mosaic, including the mild, rugose, and leaf-rolling types, leaf-roll, spindle-tuber, and curly-dwarf, are carried from diseased to healthy plants by plant lice. By sucking the juice from the sick plants these insects at the same time obtain the "virus" or disease-producing agent, which they introduce

into the healthy plants as soon as they commence to feed on them. Under favorable conditions plant lice multiply very rapidly, so that large numbers will disperse from one plant to another, thereby spreading these diseases. Consequently, the larger the number of diseased plants among healthy ones, the more favorable will be the conditions for spreading these diseases.

EVIDENCE PROVING THAT PLANT LICE TRANSMIT THESE DISEASES

Experimental evidence shows that healthy plants will develop mosaic mottling within a month after plant lice carrying diseased juice begin to feed on them. Similar results have been obtained with leaf-roll, spindle-tuber, and curly-dwarf. Such infection ex-

periments have demonstrated that 100 per cent diseased plants may be caused by plant lice moving from diseased to healthy plants.

INSECTS BESIDES APHIDS MAY TRANSMIT DISEASES

Since aphids have been demonstrated to be active agents in transmitting these diseases, it may be surmised that other insects also might carry them. Evidence in this connection has been reported from Ireland,² where preliminary tests indicate that some of the plant bugs and leaf hoppers may transmit potato leaf-roll, but this has not yet been confirmed in America.



FIG. 12.—Plants of the Green Mountain variety, showing rugose mosaic and spindle-tuber in combination and a healthy hill: (A) Hill showing combined effects of rugose mosaic and spindle-tuber; (B) a healthy hill

OTHER PLANTS BESIDES POTATO HARBOR MOSAIC

Other plants in the same family as the potato have been infected with potato mosaic; as an example of this nightshade may be mentioned. It is possible that still other species will be found as hosts of mosaic and of the other virus diseases of the potato. Even though it has been demonstrated that potato mosaic may infect other plants, it has not been proved that such plants necessarily serve as sources of infection. Observations indicate that diseased potato plants are the chief source of infection.

HILL SELECTION NEAR DISEASED PLANTS IS NOT RELIABLE

Healthy hills selected near mosaic plants when aphids are present will result in a high percentage of diseased progeny the following

² Murphy, P. A. Investigations on the leaf-roll and mosaic diseases of the potato. In Dept. Agr. and Tech. Instr. Ireland Jour., v. 23, pp. 20-34, illus. 1923.

season. It has been shown that such apparently healthy hills may produce plants with 84 per cent mosaic the following year. Similar results have been obtained with healthy hills selected near spindle-tuber plants (fig. 14). This emphasizes clearly the inadvisability of trying to develop disease-free potatoes by the selection of healthy hills from fields with a high percentage of diseased plants.



FIG. 13.—Plants and tubers of the Green Mountain variety, showing rugose mosaic and spindle-tuber in combination and rugose-mosaic hills: (A) Hill showing the combined effects of rugose mosaic and spindle-tuber. Note the dwarfing and the spindle-shaped tubers. (B) Hill showing the effect of rugose mosaic. Note that the dwarfing is less than in the plant shown in A and the absence of spindle-shaped tubers.

PLANTS FROM HEALTHY SEED POTATOES GROWN IN FIELDS ADJOINING DISEASED FIELDS MAY BECOME DISEASED

It is clear that mosaic, spindle-tuber, and similar diseases may spread very readily to near-by healthy plants. Observations on healthy stock grown in commercial fields adjoining fields having a high percentage of mosaic plants show that such healthy stock may in one season become infected with as many as 58 per cent of mosaic plants. In large fields with healthy stock adjoining diseased stock, the percentage of mosaic decreases as the distance from such diseased fields increases.

TUBER SELECTION IN THE BIN IS UNRELIABLE FOR THE PRODUCTION OF HEALTHY PLANTS

Tubers grown from mosaic, leaf-roll, and spindle-tuber plants (spindle-tuber being a result of late current-season infection) can not be distinguished from healthy tubers. The shape and size (with exceptions as noted later) of tubers from diseased hills may be like those of tubers from healthy hills.

The average size of tubers from diseased plants usually is smaller than that from healthy plants. However, there always are tubers of uniform size in both diseased and healthy lots, which makes the elimination of all diseased tubers impossible.

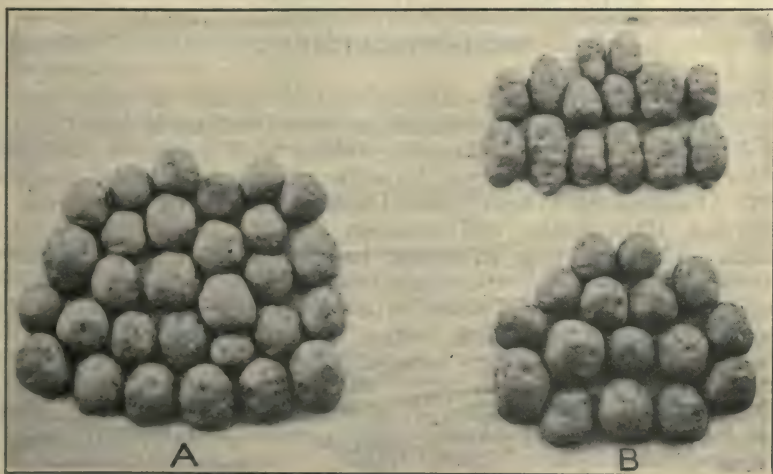


FIG. 14.—Healthy lots of the Green Mountain variety grown near spindle-tuber stock which became diseased with spindle-tuber: (A) Twenty-nine healthy tubers from as many tuber units representing stock grown during the previous season. 10 rows from spindle-tuber plants; (B) 16 healthy and 14 spindle tubers from as many tuber units representing stock grown in the same field as during the previous season five rows from the spindle-tuber plants.

Since spindle-shaped (also called “poor-shape,” “off-shape”) tubers develop spindle-tuber plants, it is possible to reduce the percentage of such plants by discarding such tubers from seed potatoes. This, however, does not insure a crop free from this disease, since the late-season infection of healthy plants in the field the previous season may introduce spindle-tuber into good-shaped tubers which will develop spindle-tuber plants if used for seed.

The presence of a considerable percentage of spindle tubers is a very good index to the grower that such stock is undesirable for seed purposes. Disease-free stock should be substituted.

SPRAYING FOR MOSAIC AND SIMILAR DISEASES

Since experience has shown that a few aphids can transmit mosaic and similar diseases, and since spraying has not controlled all these insects, control of these diseases can not be attained by spraying.

However, since it has been shown that aphids can be reduced sufficiently by spraying with a contact insecticide to inhibit direct foliage injury, and since with reduced numbers of these insects disease spread may be expected to be checked somewhat, it is suggested that a contact insecticide be applied when aphids are numerous. A commonly recommended spray formula for aphids is three-fourths pint of nicotine sulphate to 50 gallons of Bordeaux mixture. This should be applied with a high pressure (200 to 300 pounds) sprayer, using at least three nozzles per row and with nozzles adjusted so that the spray will be forced against the insects as much as possible. Nicotine dust applied under favorable conditions has been reported to produce good results. The first application should be made when the first aphid migrations appear.

SEED TREATMENT

Treating potato tubers will not control mosaic or other insect-borne diseases, the cause of which, as stated before, is found in the juice within the tubers. Treating tubers with corrosive sublimate or formalin according to the formulæ given in *Farmers' Bulletin* 1367, "Control of Potato-Tuber Diseases," will kill the germs of black-leg, *Rhizoctonia*, and common scab on the surface of the tubers. Although this treatment has inhibiting effects on these germ diseases, it does not insure a crop of tubers free from *Rhizoctonia* and common scab, since, as is well known, these germs also live in the soil, from which, under favorable conditions for their development, the new tubers become infected. Under different conditions in the various potato-growing sections, various results with these seed-tuber treatments will be obtained, and control measures best adapted to the respective localities will be developed in each section.

ARE THERE IMMUNE VARIETIES?

It would be very fortunate indeed if varieties immune to these virus diseases could be found or developed by breeding. Observations indicate that the leading commercial varieties are susceptible to one or more of these insect-borne diseases. From investigations on this important problem, the Minnesota Agricultural Experiment Station in 1921 reached the following conclusion: "During the last 34 years all named varieties of any commercial importance found in the United States and a large number of foreign varieties have been tested. No varieties have been found to be immune from mosaic-dwarf. Selections failed to isolate resistant strains within varieties."³ This significant experience emphasizes the importance of improving our commercial varieties by removing the diseased plants from partly diseased stock and maintaining disease-free stock by means of disease control, as suggested here.

³ Krantz, F. A., and G. R. Bisby. Relation of mosaic to running-out of potatoes in Minnesota. Minn. Agr. Exp. Sta. Bul. 197, p. 29. 1921.

EFFECT OF ROGUING ISOLATED FIELDS

Experience has shown that it is impracticable to try to develop disease-free stock by removing diseased plants from plats adjacent to diseased potato fields. However, it has been found that by roguing more or less isolated lots having about 5 per cent of disease it was possible to reduce mosaic in such stock to 1 or 2 per cent.

Such experiences suggest the advisability of securing from reliable sources practically disease-free stock and planting it in an isolated field or plat. By careful field inspection and roguing it has been possible to keep the percentage of diseased plants in such stock within 1 per cent.

In certain sections in northern Maine where small fields are partly surrounded by woods and by a river, healthy potatoes have been maintained practically free from mosaic and similar diseases for three seasons.

In other northern localities it has been shown that careful inspection and roguing of isolated fields resulted in the production of practically disease-free seed potatoes.

ISOLATED SEED FIELD OR PLAT

Location.—The field should be located as far as possible from the nearest field where diseases of the potato occur. The distance these diseases are carried nat-

PLANT IN ISOLATED FIELDS
SEED POTATOES FREE FROM
MOSAIC AND RELATED DIS-
EASES.

urally varies under different conditions. In northern Maine it has been found that in the same season in certain fields mosaic spread beyond 150 feet, while in other fields it spread barely 30 feet.

ROTATE TO PREVENT DIS-
EASED VOLUNTEER PLANTS
FROM INFECTING NEW CROP.

Potatoes should be rotated with other crops so that volunteer plants harboring disease will not become a source of infection to the new crop.

Source of seed tubers.—Seed tubers should be secured from sources where practically disease-free plants are grown. Potato-seed inspection and certification officials can furnish information regarding the best sources in the respective localities. It is, of course, important that such seed stock be grown in fields isolated from diseased fields; otherwise, apparently healthy stock may produce many diseased plants the following season.

Method of planting.—Field inspection and roguing will be facilitated if but one seed piece per hill is planted. Machine planters should be so operated that, so far as possible, only one seed piece per hill is dropped.

Growers who desire to have small isolated plats will find inspection and roguing more easy and effective on tuber-unit seed plats than on

those planted by machine. This, of course, means planting by hand. The tubers are cut at the time the seed pieces are dropped in the open furrow previously made by a machine. Between tuber units a skip of one seed piece is made, so that the plants from each tuber can readily be detected during field inspection and roguing. The crop from such plats can then be used for planting the commercial field the following season.

ROGUE ALL ABNORMAL PLANTS. BEGIN WHEN DISEASE APPEARS.

Inspection and roguing.—Inspection and roguing of isolated fields should be done at least three times during the season. The first roguing should take place when

the plants are not more than 6 inches above ground. Mosaic mottling in the Northern States usually appears more plainly at this period than later in the season. Furthermore, early roguing will prevent aphids from transmitting diseases from sick to healthy plants later in the season. Early roguing when aphids are few will also tend to produce less infection by fewer insects falling from rogued plants while being taken from the field than would occur later when aphids are more numerous.

The second roguing should follow about 10 days after the first, and the third roguing about two weeks after the second. If any varietal mixtures are present the field or plat should be inspected during blossoming time, when such plants can best be detected and removed.

During these field inspections all diseased plants, including tops, seed pieces, and new tubers, should be removed from the field or plat. All plants showing mosaic mottling or other abnormal symptoms, or dwarfing, wrinkling, rolling, spindliness, and streaking, should be carefully removed from the field and destroyed or deposited at least several hundred feet away from the field, so that any transmitting insects on the rogued plants may not produce new infections.

Spraying.—Bordeaux mixture combined with contact and poison sprays for the control of plant lice and other insects should be applied as soon as these pests appear and should be repeated as many times as seasonal conditions may require. (See Farmers' Bulletin 1349, "Increasing the Potato Crop by Spraying.")

Cultivation.—Keep potato fields free from all weeds, thereby providing favorable conditions for the growth of the crop and facilitating inspection as well as providing against the possibility that some weeds may harbor the virus diseases.

PRACTICE CLEAN CULTIVATION.

COOPERATIVE SEED-POTATO PRODUCTION

In view of the fact that one of the promising methods of producing disease-free seed potatoes consists in growing them in fields isolated from diseased stock, and since this is very difficult for

growers whose neighbors may have diseased stock, it is suggested that growers who are interested in the production of high-grade disease-free seed stocks cooperate with their neighbors in order to bring about a community interest.

If community cooperation can be secured to insure the planting of none but disease-free seed within the range of aphid spread—or approximately one-fourth mile from seed-potato fields—the problem will be much simpler.

The growing of one and the same variety or at most two varieties would also tend to simplify the production and maintenance of disease-free stock, and by growing such stock on a community basis the marketing problem could be handled more easily and economically.

Different communities should grow the variety or varieties which experience has shown to be best adapted for their section.

CERTIFIED SEED POTATOES

By carefully observing methods for the production of disease-free potatoes as indicated here many growers in the northern seed-potato-growing localities have succeeded in producing certified seed potatoes. Since experience has shown that planting these potatoes results in yields superior to carelessly selected commercially grown potatoes, careful buyers of seed potatoes demand certified stock, for which a premium is generally paid.

SUMMARY

Deterioration, or running out, of potatoes is largely caused by diseases.

Mosaic, leaf-roll, spindle-tuber, curly-dwarf, and streak are insect-borne diseases chiefly responsible for the so-called running out of potatoes.

These insect-borne maladies cause losses in yield ranging from 15 to 70 per cent and practically a total loss in severe cases.

Mosaic, leaf-roll, spindle-tuber, and curly-dwarf have been reported from important seed-potato-growing sections of the United States.

Plant lice carry mosaic, leaf-roll, spindle-tuber, and curly-dwarf from diseased to healthy plants. Other insects have been reported to transmit leaf-roll.

Experience indicates that mosaic and leaf-roll are not carried in the soil.

Transmission of mosaic, leaf-roll, spindle-tuber, and curly-dwarf from diseased to healthy plants has been demonstrated by means of tuber and stalk grafts and, with the exception of leaf-roll, by juice inoculations.

Tubers from diseased plants always produce the disease in the new plants.

Tubers from mosaic and leaf-roll plants can not be distinguished by their general appearance from those of healthy plants. The same holds true with tubers from an apparently healthy plant which contracted spindle-tuber late in the growing season.

Tubers from plants grown from spindle-tuber plants can be recognized by their spindle or "run-long" shape. A large percentage of such tubers is a good index of the undesirability of stock for seed purposes.

Hill selection of apparently healthy plants in fields having a high percentage of these insect-borne diseases where aphids and possibly other insect carriers are numerous will usually result in a crop with many diseased plants.

Bin selection of tubers from fields having a high percentage of these insect-borne diseases will result in a badly diseased crop.

Observations indicate that besides the potato other plants in the nightshade family as well as in other families harbor mosaic.

Observations have disclosed that mosaic mottling is modified by climatic conditions, but that such modifications are not an indication of freedom from disease in these plants.

Healthy stock planted beside or near potatoes having a high percentage of these insect-borne diseases when aphids and possibly other insect carriers are numerous will become diseased. Most of the symptoms of disease will appear in the next year's crop.

Experience has shown that it is impracticable to attempt the production of healthy seed potatoes by removing diseased plants from plats or fields adjoining those with a high percentage of diseased plants when aphids are numerous.

The leading commercial varieties of potatoes are susceptible to one or more insect-borne diseases. This emphasizes the importance of producing and maintaining healthy lots of these varieties for seed-potato production.

By careful field inspection and roguing under isolated conditions in certain northern localities, it has been possible to produce and maintain for a few seasons practically disease-free seed potatoes.

The isolated tuber-unit seed plat is recommended as an aid in the improvement of seed potatoes. It is suggested that the production and maintenance of disease-free seed stock can be accomplished very advantageously by the close cooperation of interested growers in community groups.

Careful inspection of the plants during the entire growing season is more important than any single procedure for securing information regarding these insect-borne diseases. At that time it is possible to detect these maladies, so that diseased plants can be removed, as is done in the seed field or plat, or in case of a high percentage of disease the stock can be condemned for seed purposes.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

October 10, 1924

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1437

SWINE
PRODUCTION



U. S. DEPARTMENT OF AGRICULTURE
BULLETIN NO. 874

THE HOG is by far the most valuable farm animal in utilizing farm wastes and in converting the concentrates raised on the farm into a marketable product.

Farmers of the prosperous parts of the country long ago recognized the merit of the hog as a money-maker. Farmers in certain other parts of the country who heretofore have been confining their efforts to grain production are beginning to look to the hog for assistance to make ends meet or to produce a profit.

Without the hog, profits in the big cattle-fattening industry of the Central West would be jeopardized.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 874, Swine Management.

Washington, D. C.

Issued March, 1925

SWINE PRODUCTION

By E. Z. RUSSELL, *Animal Husbandman, in Charge of Swine Investigations,
Animal Husbandry Division, Bureau of Animal Industry*

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HOG-GROWING SECTIONS OF THE UNITED STATES

ALL REGIONS of the United States may be considered suitable for raising hogs, inasmuch as feeds used to grow and fatten hogs can be produced to a greater or less extent in practically every part of the country.

That section of the country commonly called the Corn Belt is superior to other sections because of the fact that corn, the principal feed used in fattening hogs, is produced in such abundance. In addition to corn, alfalfa, which is undoubtedly the best pasture plant for hogs and the best relished hay crop, can be produced in most parts of the Corn Belt. Many other pasture plants on which hogs do well also can be grown successfully in this section.

It is a common mistake to think that hogs can not be raised successfully in some parts of the country. Corn is not the only feed on which hogs will fatten. In some years there is such a large surplus of corn in the Corn Belt that it is a disadvantage to the hog producer. A supplement containing a considerable amount of protein (bone and muscle building material) should be fed in addition to corn. Such protein is usually fed in the form of tankage, fish meal, shorts or middlings, or old-process linseed meal, all of which must be purchased. Oftentimes these feeds are high in price when corn is low, and in consequence the low-priced feed is used exclusively, without the best results. Alfalfa contains a higher percentage of protein than other pasture plants in common use, and this fact makes it more valuable as a pasture and also as a hay for hog feeding.

The Corn Belt is the source of supply for large quantities of pork products, particularly hams, bacon, and shoulders, that are consumed in other parts of the country. In recent years farmers of the Southern States have been giving the question of hog growing a great deal of study, with the result that the business is increasing in that section. In most parts of the South an abundance of pasture crops can be produced, which is a distinct advantage in raising hogs. In some sections hogs may be on pasture 12 months in the year. Cowpeas, soy beans, and peanuts are leguminous crops that can be successfully grown in different sections. Corn grows readily

in many sections, and feeders report success with cassava, chufas, and sweet potatoes.

On many farms, particularly in the New England States and on specially equipped feeding lots near large cities, the feeding of garbage is carried on somewhat extensively. Garbage-fed hogs do not make so rapid gains as corn-fed hogs, but they produce pork of equally good quality. Farmers' Bulletin 1133, *Feeding Garbage to Hogs*, discusses this subject in detail.

Soy beans are a rich protein feed, and should be fed only when supplemented by corn or some other carbohydrate. When soy beans are fed alone satisfactory gains will not be made, and if fed alone for any considerable time the hog carcasses will not be firm. Extensive experiments conducted by the United States Department of Agriculture cooperating with the State agricultural experiment stations of most of the Southern States showed that when hogs starting at approximately 100 pounds weight are fed peanuts alone for 60 days a soft carcass is produced and that it is impossible to produce a hard carcass by feeding corn and tankage or corn and cottonseed meal to soft hogs for a subsequent period of 60 days.

Later results have shown that 100-pound pigs fed on peanuts during a period of 60 days are made firmer by subsequent feeding of hardening feed. However, it is yet impossible from these data to recommend a practical method of producing a strictly hard carcass from such hogs. The products of soft hogs are such that the packers discriminate against them. In some sections the deductions in live-weight price from standard hard hogs are 1 cent a pound for hogs that grade soft and 2 cents for those grading oily; in other sections 2 cents is deducted for soft or oily hogs, while at other markets a 3-cent deduction is made. However, these deductions should not discourage the production of hogs in peanut-growing sections, as in many cases the reduced price may be accepted and still the producer will be able to show a profit.

In many of the great valleys of the Western States, especially in the irrigated sections, barley and wheat, both of which are used in fattening hogs, grow in abundance. These lands produce good alfalfa, which makes hog growing a possible and profitable business. At the present time a considerable percentage of the hogs slaughtered in the packing plants of the Mountain and Pacific Coast States are shipped from the western part of the Corn Belt. Most of these hogs could be profitably grown in the Western States or near the slaughtering points.

Milk and milk products are always valuable as supplementary feeds for hogs, but should not be used as the whole ration. These products are not necessary for the successful production of hogs, though in dairy districts they form an important part of the hog's ration and are recommended where they may be obtained at a suitable price.

Skim milk and milk by-products, however, may contain disease germs, especially those of tuberculosis, and should be sterilized by cooking before feeding to hogs unless they are known to come from cows that have been tested and found free from this disease.

LOCATION OF FARM FOR HOG RAISING

The feeds necessary to grow and fatten hogs should be given first consideration when the question of location of a farm for hog raising

is being considered. Feeds can be produced more abundantly in some localities than in others. Other factors, such as markets, climate, and quality of soil, also should be studied. Sanitary conditions are more favorable where the land is rolling. If the farm is level and flat, it is advisable to throw up ridges with a scraper or road grader and to feed and house the hogs on these ridges. Good roads and accessibility to market are always to be considered.

NUMBER OF HOGS FOR A FARM

When beginning the hog business, it is best to start with but a few sows, and as the herd increases in numbers a careful study of the farm should be made to determine what crops it will produce most successfully and how and to what extent hogs fit into the general plan for that particular farm. The study of these problems will soon indicate the number of brood sows which can be kept to farrow each year to make the most profit. When this conclusion is reached, this number of sows should be adhered to as nearly as possible year after year. Market prices for hogs or for feeds used in fattening hogs taken alone should not be allowed to determine the number of sows to be bred at any breeding season. The fact should always be kept in mind that prices for both hogs and feed may change very greatly before the time comes to sell the next crop of pigs. The amount of available by-products, such as skim milk, shattered grain from grain fields, unmarketable products from the truck farm, undigested grain in the droppings of fattening steers, and other minor wastes of feed should be taken into consideration when calculating the number of hogs to be raised yearly.

SELECTION OF BREEDING STOCK

It is always advisable to use purebred animals in founding a herd. Too much valuable time and money are lost by starting with low-grade sows and expecting improvement by use of purebred boars. Considering the rapidity with which hogs multiply, the initial cost of one or more good, purebred sows of either the bacon or lard type as foundation animals is such that the outlay is a good business investment.

THE SOWS

In making the purchase of the foundation sows attention should be given to the type of animals to be used. Select sows of uniform type, of the same breed, similar in color, marking, and conformation. Sows of good type and conformation may be found in all the standard breeds. It is generally advisable to buy sows already bred when buying foundation animals. Tried sows or gilts may be used. Too often not enough attention is given the sows in the herd. Hog men depend too much on the boar to produce the quality and type of hogs desired. An old, experienced hog man once said to the writer, "Show me the sows in the herd and I'll tell you the kind of pigs that will be produced." There is a lot of truth in this statement. (See fig. 1.)

First of all, the sow should show femininity. She should have a rather thin neck, good, clear eyes, ears of fair size, yet controlled so they will not cover the eyes and obstruct the sight, and a clean "sow" face, with good width between the eyes. She should be up-

standing, with legs of sufficient length so that the udder will not touch the ground when she matures. The back should be well arched, not too broad. She should have good, smooth, deep sides, and well-rounded hams. The udder should be well developed and have two rows of teats, at least six in each row. Her legs should be strong and well placed under the body, with good feet and short, strong pasterns. Particular attention should be given to the heart girth. It should be full and smooth, with no depression showing behind the shoulders.

The disposition of the sow should receive careful attention. A good brood sow will permit the attendant to be in the pen with her at any time. A cross, nervous, or irritable sow is undesirable and should be eliminated from the herd as soon as practicable. This trait may be hereditary, so it is advisable not to retain the pigs from such a sow in the breeding herd.



FIG. 1.—Quality as shown in a brood sow (left) and three of her produce

A careful selection of sows raising good-sized litters of pigs that grow out well will soon establish a breeding herd of value. It is not good management to follow the practice of using gilts, having them produce one litter and then fattening all of them for market. The continuous use of immature breeding animals is apt to reduce the vitality and quality of the herd. It prevents also the building up of a good herd of producing sows which have been selected because of their ability to raise good litters of strong, thrifty pigs.

The function of a brood sow is to produce pigs at a profit. The cost of keeping a sow on the farm is the same regardless of the number of pigs she produces. If a sow raises eight pigs to the weaning age, she is more profitable than if she raises only five; therefore prolificacy is a very important essential in selection. Not only the sow to be placed in the herd, but the dam and granddam as well, should come from good-sized litters. If the sow selected is a tried sow, her performance in production should be satisfactory.

Uniformity in type, color, and conformation is highly desirable. This can usually be secured best by making the purchases from one herd. The produce of each individual sow should be observed, and

when pigs from any sow do not conform to the type and growth of the general herd she should be replaced by a gilt from a sow whose pigs show good type and feeding qualities. Careful selection and the elimination of undesirable individuals will enable the grower in a few years to produce animals of uniform type and feeding qualities, which in turn command a better price on the market.

THE BOAR

The selection of a boar is probably one of the most important things that the hog raiser has to do. If possible, everyone having breeding sows should have a boar, although when one has only three or four sows and arrangements can be made with some near-by neighbor who has a boar, it may be advisable not to make the necessary outlay to purchase one. It is very unsatisfactory, however, to take the sows off the place for breeding. Better success will be obtained in getting them "settled" if they can be mated on the place.

Careful study should be made of the sows in the herd in order that faults in conformation may be noted. When the boar is purchased he should be selected with the idea of correcting these faults to as great an extent as possible. It is undoubtedly true that "the boar is half the herd," but success can not be obtained unless quality and type of both the sows and the boar are given careful consideration.

Selection of the boar should be deferred until he is at least six months old. At that age a boar is generally so developed that serious faults may be seen. To tell the outcome of a suckling or weanling pig is practically impossible. It is always advisable in purchasing a boar to see the sire, the dam, and other animals in the herd which are closely related to the one under consideration.

It is better to purchase a tried boar if one of the right type and conformation can be obtained at a reasonable price. If a tried boar is under consideration, the pigs he has sired should be carefully observed to see whether his particular qualities have been transmitted. A boar with good conformation is not always a good sire.

A boar used as a sire should not be discarded until the growing and feeding qualities of his get are determined by a test in the feed lot. Sires of superior quality are not numerous. When the practice is followed of using a boar one season and then marketing him many a valuable sire is sent to the block that should have been retained in the herd.

A boar should not be used before he is 8 months of age, and if he proves a superior sire should be retained in the herd until in the judgment of the owner he should be discarded, which may be at the age of 6 or 8 years or even older (fig. 2).

A herd boar must be handled frequently; consequently his disposition must be given careful attention. A cross, irritable boar, difficult to drive or inclined to fight, should not be selected unless he has some extraordinary qualities that are urgently needed in the herd.

The boar must show masculinity. This is characterized by a strong, wide head, a short, thick, well-crested neck, well-developed shoulders, a strong, well-arched back, well-sprung ribs, and a good covering of flesh. The hair of the boar is generally coarser than that of the sow. His hams should be round and full, his sides even and smooth. Wrinkles or creases in the sides and shoulders are very

objectionable. He should by all means have strong feet and legs. The bone should be of good quality and of sufficient size to carry easily any weight that he may attain. Particular attention should be given to the pasterns, which should be short and straight. When standing at some distance in front of a boar one should easily be able to distinguish him from a sow. His reproductive organs should be clearly visible and well developed. A boar with only one testicle should never be selected.

MANAGEMENT OF THE BOAR

The careful attention of the herdsman is required during the breeding season. An inclosure, preferably under cover, should be provided, in which a breeding crate is placed, and where all the sows should be taken to be bred. A boar carefully and properly handled soon becomes accustomed to a breeding crate and more successful services will be obtained by its use. He should never be



FIG. 2.—Boar of a desirable type

allowed to run with the sows during the breeding season. He should not be confined to a small pen, but should have the run of a good-sized lot or pasture. The boar lot should be convenient to the breeding pen. It is also desirable to have the boar lot so located that breeding sows or other hogs are not placed in adjoining lots or fields. During the breeding season the boar should be undisturbed as much of the time as possible.

One service to each sow is sufficient. A young boar should not be allowed to serve more than one sow each 24 hours. It is best for an aged boar not to serve more than one sow a day, but if necessary a strong, vigorous, aged boar may serve two sows in a day, breeding one early in the morning and the other late in the evening.

The feed given the boar during the breeding season should be abundant and of good quality, in fact all he will clean up twice daily. It is advisable to feed corn in addition to a thick slop of middlings or shorts, to which may be added a small quantity of tankage, fish meal, or old-process linseed meal. When pasture is

not available, alfalfa hay of good quality should be supplied in a rack. Salt and mineral mixture should also be provided.

If a boar becomes restless and gets to "ranting," the trouble may sometimes be overcome by placing a bred sow in the lot with him. Occasionally during the breeding season a boar goes off his feed. If this occurs, put a young boar pig in his lot. The boar frequently will eat the feed offered to keep the pig from getting it.

After the breeding season is over the feed of the boar should be reduced so that he will just keep in a good, thrifty condition. Only a small quantity of corn should be fed at this time, his main feed being middlings or shorts, oats, or a little linseed meal, with the run of a good pasture.

AGE FOR BREEDING SOWS

The age at which a gilt should be bred to produce her first litter may depend somewhat on her development. If the breeder is to get the best results he should select only growthy, well-developed young sows. A well-developed young sow can be bred safely when she is 8 months old, but it is not advisable to breed her before that time. Sows bred at too young an age seldom produce as they should, frequently have trouble at farrowing time, and do not make the best growth after weaning their first litters.

It is advisable not to breed a sow to farrow in the fall after she weans her first litter in the spring at an age of about 12 months. She should have the entire time between weaning her spring litter and being bred in the fall, for growth and development. After she is 2 years old, however, she is fully capable of producing two litters a year.

A brood sow that produces a good-sized litter that is profitable in the feed lot or breeding herd should be retained as long as her usefulness continues. This is often from 6 to 8 years, sometimes longer. The writer had one sow that produced a good litter at the age of 11 years.

A sow will generally farrow in from 112 to 115 days after the day she is bred. In some instances she will farrow in 110 or 111 days and sometimes she may go a few days over 115. By keeping a careful service record, the breeder will be able to determine quite accurately when to expect the pigs and to make his arrangements accordingly. The gestation table on p. 8 is based on a period of 112 days. The first line of dates in each column indicates the dates of breeding and directly opposite is the date on which the sow is due to farrow.

MANAGEMENT OF SOWS DURING PREGNANCY

The result of the year's work with hogs depends more largely on the management and feeding of the sows during pregnancy than during any other period. If the sows are not properly conditioned for farrowing, the pigs will not get a good start, and consequently can not make the growth and profit that they should. Suitable feed and ample exercise are the two most important factors of care during pregnancy. Housing, bedding, and watering have their place and must be given careful attention. In addition to the brood sow keeping up her own bodily functions she must develop the litter. If this is accomplished, a variety of the right kinds of feed must be

given her. She must be in the best possible condition at farrowing time; and even though given all the feed she will eat, she will not be too fat. The principal common feeds used for brood sows are corn, shorts or middlings, fish meal or tankage, old-process linseed meal, bran, alfalfa hay or meal, oats, and barley. Corn is the most common and most important feed used and when fed judiciously with the right combination of the above-mentioned feeds will produce the best results.

Proper management at this time requires that feeding and exercise be linked together. It is better to produce the exercise through a system of feeding than by driving the sows around the lots or fields. A good method to follow is to give the sows all the corn they will eat by scattering ear corn in the stalk fields, requiring them to find it, an ear at a time. In this way they will not get too much and will get the necessary exercise in hunting it. This method may seem wasteful, but it is not, as the sows will get the corn, even though it may be covered to some extent with snow. A clean manure spreader set to scatter the corn thinly is a way to haul it.

A good method of feeding shorts or middlings is to place them in a self-feeder some distance from the water supply and sleeping quarters, allowing the sows to eat all they want. At a convenient place between the waterer or sleeping quarters and the self-feeder place a rack filled with good alfalfa hay, preferably the third or fourth cutting. If this plan of feeding middlings and hay is followed, the corn may be fed twice daily in troughs or on a feeding floor. Mineral mixture should be supplied all the time in a self-feeder.

CARE OF SOW AND PIGS AT FARROWING

About three days before a sow is due to farrow she should be confined to the pen or house where she will be during the farrowing period. The pen should be thoroughly cleaned. It should be dry, well ventilated, about 7 by 7 feet in size, and provided with a guard rail made by placing 2 by 4 inch pieces around the inside of the pen about 10 inches from the floor and from 4 to 6 inches from the sides (fig. 4). This will often prevent the sow from crushing a pig when she lies down.

Remove all the bedding, sweep the floor and sides, and wash with scalding water and lye. When dry, bed the pen with good, clean, dry bedding. Wheat or rye straw, short or chopped hay, and shredded corn fodder are good. Do not use oat straw, as it retains moisture and becomes foul too easily. The quantity of bedding to use should be determined generally by the condition of the weather and by the sow herself. She should be made comfortable. If too little bedding is used, the sow will keep getting up and trying to collect it in a bunch in order to keep herself and the pigs warm.

The sow generally becomes nervous and restless as parturition approaches. She makes a nest for her young. Milk comes down in the teats. Before putting the sow into the pen all mud and filth, especially on her udder, should be removed by washing with soap and warm water. (Fig. 5.)

An attendant should always be at hand during farrowing to give any needed assistance. When farrowing occurs during cold weather a box or a basket should be provided, lined with sacks or other

cloth. In the center of this place warm bricks or a jug of hot water wrapped in cloth to protect the young pigs. (Fig. 6.) The receptacle should be lightly covered to hold the heat. As the pigs



FIG. 3.—Cleaning and disinfecting the farrowing pen before placing the sow in to farrow

arrive they should be thoroughly dried, the navel cord tied with a common cotton string about an inch from the belly, and the cord cut just below the tie. It is good practice to treat the raw edges



FIG. 4.—A well-bedded farrowing pen protected by a guard rail

of the wound with tincture of iodine. After this treatment the pigs should be placed in the box or basket until all are farrowed,



FIG. 5.—Washing the sow's sides and udder before farrowing

provided the time is not more than two or three hours. If farrowing is prolonged, place the pigs to the sow, let them nurse, and return them again to the box or basket.

If any of the pigs appear to be lifeless when born, immediately remove all mucus from the nose, then give them a few gentle slaps on the side with the hand. This may start breathing if there is any life in the body.



FIG. 6.—Protecting the newborn pigs against chilling in cold weather. Jug contains hot water

A pig is born with eight small tusklike teeth, four in each jaw. These should be cut off before the pigs are placed with the sow to nurse. Care should be taken in cutting these teeth not to injure the jaw or gums. Use sharp, side-cutting pliers, cutting about halfway between the jaw and the point of the tooth. Do not attempt to break or pull them. They are very sharp, and if not cut the pigs may bite the sow's teats when nursing, causing her to jump suddenly, possibly injuring or killing some of the pigs. Another reason is that the pigs may bite or scratch one another, allowing infection to start and causing serious trouble. (Fig. 7.)

Each farrowing pen should be supplied with an outside feeding pen or floor, away from the little pigs, where the sow may be fed. This pen should be as wide as the farrowing pen, extending 6 or 8 feet from the building. If the feed is supplied in the farrowing pen, the sow is very apt to cripple or kill one or more of the little



FIG. 7.—Cutting the baby teeth before nursing will help to prevent injuries by young pig

pigs while eating. On the other hand, if the sow is fed outside, she will deposit her droppings there, preventing the bedding from becoming foul or wet.

It sometimes happens that when the sow farrows she will not have any milk. When such cases occur the newly farrowed pigs should be fed cow's milk, undiluted, in small quantities at about 2-hour intervals. This milk may be fed with a nipple or by pouring a small quantity, not more than half an inch in depth, into the bottom of a thoroughly cleaned shallow tin pan. The pigs will rub their noses in the milk and soon begin to drink. Care must be taken not to overfeed them, especially when they are only a few days old.

SOWS THAT EAT THEIR PIGS

It is not natural for a sow to eat her pigs. The desire to do so may result from several causes. It is probably because she has not

been properly fed and cared for during pregnancy. Plenty of exercise and feeds such as are described under "Management of sows during pregnancy" will usually prevent this trouble at farrowing. The afterbirth should be removed from the farrowing pen and burned or buried. Care should always be taken to see that the bowels are in proper condition. If they are not, feed a sufficient quantity (about a pint) of linseed meal or a handful of Glauber salt dissolved in the drinking water or slop.

THE SOW'S FEED

Reduce the richness and quantity of the sow's feed by at least half 24 hours before she farrows. She should have no feed during the first 24 hours after farrowing, but because of her feverish condition she should have plenty of lukewarm water at frequent intervals.

After 24 hours the sow should be given a small feed of a light slop of shorts or middlings, and the same feeds she has had during pregnancy should be continued. The pigs should be closely examined before each feeding of the sow until they are about 10 days old for any appearance of white scours or diarrhea. If this trouble appears, discontinue feeding the slop and give the sow a small quantity of oats, scattered thinly on the floor. Prepare limewater by dissolving a piece of rock lime about the size of a baseball in a gallon of water; after it settles drain off the water and give it to the sow to drink; also bathe the sow's udder and teats with some of the limewater. The pigs which are scouring should be given five drops of diluted formalin (on the tongue), prepared by mixing 1 ounce of standard strength formalin and 1 pint of water.

The feed of the sow should be gradually increased, adding some corn to the ration about the third or fourth day after farrowing. When the pigs are from 10 days to 2 weeks old she should be on full feed and have all the good feed she will eat. She should then be removed from the farrowing pen to a lot or field containing good pasture of some sort, if pasture is available; if not, move her to some quarters other than the farrowing pen. If possible, the new quarters should be where no hogs have been during the last year or on ground that has been plowed since hogs were there.

Until the pigs are weaned the sow should be given special care. It is not possible to say how much feed she should have; but if best results are obtained in growing the pigs, she must have all she will clean up twice daily in addition to pasture. Corn or ground barley should be the main feed, supplemented by shorts or middlings, tankage or fish meal, or old-process linseed meal. The corn may be fed on the ear or shelled. The other feeds may be fed dry or in slop. Abrupt changes of the feed of hogs of any age should be avoided. When a change of feed is necessary, make it gradually by slowly reducing the former feed and increasing the new feed. A box or self-feeder containing the mineral mixture suggested on page 21 should be available at all times.

MANAGEMENT OF PIGS DURING SUCKLING PERIOD

During the suckling period sows and pigs should always be provided with dry, warm, well-bedded sleeping quarters, where they

may go in comfort at any time. The bedding must be watched carefully and changed whenever it becomes foul or wet.

The hog is one of the best and most profitable means of converting the grain and a part of the pasture crops of the farm into edible meat. If the greatest profit is to be returned to the feeder, the pigs must make maximum gains all the time. The profitable pig is one that never stops growing from farrowing to market.

When pigs are about three weeks old they will need something to eat in addition to the mother's milk. A creep should be provided containing a self-feeder filled with shelled corn. When constructing the creep leave an opening at one or more places sufficiently wide and high to permit the pigs to walk in and out freely. Build the sides close to the ground so that they can not crawl under. (Fig. 8.) If pigs



FIG. 8.—A creep should be so arranged that the pigs may get their feed undisturbed

enter the creep by crawling under there is always an unnecessary waste of energy, and poor development of the backs of such pigs occurs. There should be free access to a mineral mixture (see p. 21) by placing it in a small self-feeder at the end of the larger one or supplying it in a separate compartment of the grain feeder.

When the pigs are about five or six weeks old, some protein supplement to the corn should be provided. Shorts or middlings of good quality are very desirable for this purpose. This feed should be fed separately from the feeder and not be mixed with the corn. Tankage or fish meal or old-process linseed meal may be used as a substitute for shorts or middlings.

At the United States Experiment Farm, Beltsville, Md., sows suckling their pigs have been fed for three years by a self-feeder contain-

ing shelled corn, middlings, and mineral mixture in separate compartments. The results have been as good as or better than by hand feeding twice daily. (Fig 9.)

THUMPS

The term "thumps" as here used refers to a peculiar yet well-known spasmodic action of the diaphragms of pigs less than three weeks of age; it is not necessarily associated with respiration. Little pigs must be watched closely for the appearance of this condition. It usually occurs when they are from 5 to 15 days old and is caused by their overfeeding and not taking sufficient exercise. The fattest, best pigs in the litter are the ones to be affected first. Plenty of exercise and sunshine will prevent the trouble. If the weather is bad and the pigs do not get out, they must be forced to take exercise. Use a switch and chase them around the pen or along the alley of the hog house until they become tired. Repeat this three or four times a day until the threatened trouble disappears.

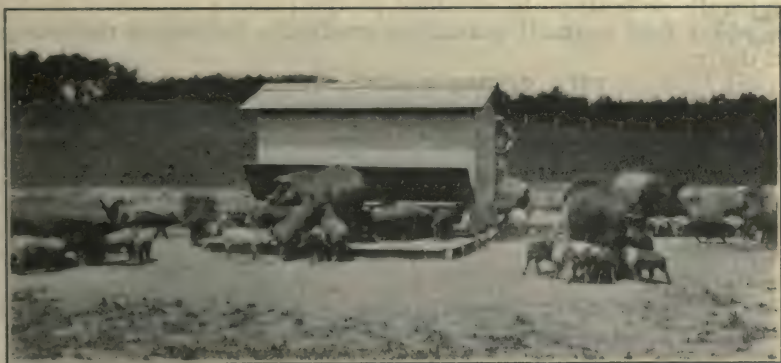


FIG. 9.—Self-feeders may be profitably used for sows and pigs during suckling period.

CASTRATION

Pigs should be castrated while they are still suckling their dams—early enough to allow plenty of time for the wounds to heal thoroughly before weaning. For detailed information on this subject consult Farmers' Bulletin 1357, *Castration of Hogs*.

WEANING THE PIGS

Hog raisers differ widely in their opinions as to the proper age at which pigs should be weaned. Pigs are weaned at all ages from 5 to 12 weeks, or even older. The mother's milk is the natural and best food for a pig and should be used to the greatest extent possible. A good brood sow properly fed and handled will furnish a good flow of milk until the pigs are from 10 to 12 weeks old. A sow that will not suckle well for this period should be discarded from the herd.

Unless there is some special reason for doing otherwise, pigs should not be weaned until they are at least 10 weeks old. Some breeders wean at an earlier age to get two litters a year. Generally this is not necessary. A better practice is to raise three litters in two

years. A pig that is stunted by early weaning or from any other cause will never make so profitable a hog as it would if this setback had not occurred.

When the pigs are to be weaned, reduce the richness and quantity of the sow's feed four or five days before weaning. This will have a tendency to reduce the flow of the milk. Then remove the sow from the pigs, leaving them in the same quarters where they were during the time they were suckling, with access to the self-feeder.

If the sow is handled in this manner it will seldom be necessary to milk her to prevent a caked udder. If the udder becomes too full, return the sow to the pigs to suckle and remove her as soon as they have finished. It is rarely necessary to return the sow to the pigs more than once.

After the pigs are weaned do not change the ration. Leave them on good pasture, with access to the self-feeder containing corn, shorts or middlings, tankage or fish meal, and mineral mixture. If at any time while the pigs are suckling or after they are weaned skim milk or buttermilk is added to the ration; commence feeding the added feed in small quantities, gradually increasing the amount fed daily.

THE SOWS AFTER WEANING

After the pigs have been weaned the sows should be placed in pastures and given a small quantity of grain. The quantity of grain needed must be determined by the quality of the pasture and the condition of the sows.

Sows two years old or over which have weaned spring litters and which are not bred for fall farrowing may be successfully carried on good alfalfa or clover pasture without grain for from two to three months. Very thin sows and gilts weaning the first litter should be separated from the others, placed on good pasture, and given a liberal grain ration. The thin sows will generally gain rapidly enough to be taken out in 30 days, but it is desirable to feed gilts some grain during the entire period between the weaning of their first two litters.

All hogs require close attention, regardless of age or sex, but the best proof of the herdsman's skill is in caring for and managing the brood sows of the herd.

TWO LITTERS A YEAR

The question of raising two litters a year is one on which no positive advice can be given. Much depends on where the hog grower is located, his equipment for handling pigs during the winter, how the scheme fits into his farming operations, and other local problems. Fall pigs require a great deal of attention, and most farmers are not in position to care for as many fall pigs as spring pigs. The age at which pigs are weaned has much to do with raising two litters a year. Best general results will be obtained if pigs are allowed to nurse their mothers for at least 10 weeks. (This question is discussed more fully under "Weaning.")

In the northern half of the United States fall pigs should not be farrowed after October 15. If farrowed at a later date, they will not have sufficient time to become well started before cold weather sets in. Throughout the country a large percentage of the spring

pigs are farrowed in March and April and fall pigs in September and October. If a sow farrows March 15 and the pigs suckle 10 weeks, they will be weaned May 24. If the sow is in good condition, she will come "in season" three or four days after the pigs are weaned and may be immediately rebred. If she is rebred May 28, she will farrow September 16. These pigs would be weaned November 25, which would allow rebreeding for farrowing March 20. It is not always possible to get a sow settled at the first service and this uncertainty makes it difficult to assure farrowing at the proper time; therefore the raising of two litters a year from all the sows in the herd is impossible.

If the pigs are allowed to suckle 10 weeks, as they should be, it is easily possible for a good sow, on the average, to raise three litters every two years. This is a good average and would probably meet the requirements of most farmers and show the best net profits in the end.



FIG. 10.—Sows and pigs on rye pasture

FALL PIGS

Pigs farrowed in the fall require more attention than those farrowed in the spring. This applies more particularly to the northern part of the country than to the South. During the winter in all parts of the country fall pigs should have easy access to comfortable, dry, well-bedded quarters. In the North, where snows are frequent, pigs running in and out naturally carry in more or less moisture, causing the bedding to become damp. Pigs should never be required to sleep in damp bedding; consequently the bedding must be watched closely and changed often.

A constant supply of water is always needed. In cold regions the open-trough plan of watering is seldom efficient. An automatic, heated waterer should be provided.

In the southern part of the country winter pasture of some kind can generally be provided. Fall pigs, as well as other hogs, should always have access to winter pasture. (Fig. 10.)

HOG PASTURES

Pastures for hogs are valuable and should be utilized to as great an extent as possible. The best use of pastures, however, does not mean that hogs fatten or even make satisfactory growth on pasture alone. Pastures of any kind, regardless of quality, must be supplemented with grain if the most satisfactory results are to be obtained.

The hog grower should never attempt to supply only just enough pasture. Pastures will not produce the best results if they are grazed closely. Only as many hogs as can be provided with an abundance of feed should be placed in any lot or pasture. It is impossible to say how many animals may be grazed on an acre, since so much depends on the crop used, the quality of the soil, and climatic conditions. Ordinarily an acre will furnish pasture for from 5 to 15 hogs averaging 100 pounds. It is a good plan to have two pastures for each lot of hogs. By alternating them the pastures may be grazed fairly closely and still provide good, succulent feed.



FIG. 11.—A breeding herd on alfalfa pasture

Pasture crops that are allowed to mature do not furnish good feed for hogs.

The fertilizer value of the manure which is left on the land is an indirect and generally unnoticed value that should be taken into account when hog pastures are being considered. Hogs on pasture range all over the inclosure; consequently the distribution of the manure is quite uniform. Furthermore, very little of it is lost. The value to be derived from hog pastures does not apply to any particular locality or section of the country. The only difference in different sections is the length of the pasture season.

The value of good pastures to breeding animals can not be overestimated. To give a maximum of efficiency the breeding sow and boar must have exercise and a variety of feeds. There is no other way by which exercise and variety of feeds can be supplied as well as by giving the animals free range on a good pasture. (Fig. 11.)

PERMANENT PASTURES

In most of the hog-growing sections of the country permanent pastures are generally used by hog raisers. It is not advisable, however, to use any of the permanent pasture grasses in small lots or

where a considerable number of hogs are kept on them during most of the pasture season. Where hogs are kept in any considerable numbers in an inclosure it is always advisable to plow such lots or pastures once each year, though twice a year is better.

Many successful hog growers place on their permanent pastures only a limited number of hogs, such as will permit the pastures to make a sufficient growth to produce a crop of hay. Plants most generally used for permanent pastures are alfalfa, red clover, alsike, white clover, bluegrass, bur clover, Bermuda grass, lespedeza, carpet grass, crab grass, and Dallas grass. The first five are used in the northern half of the United States. Bluegrass and white clover are generally grown together. Timothy is often grown with red clover. The other plants are grown in the southern parts of the country. All the plants grown in the North are to a greater or less extent grown also in the South. Of all the permanent pasture plants alfalfa undoubtedly heads the list for hogs. In localities where this plant can be successfully grown no other permanent pasture is necessary.

TEMPORARY PASTURES

Temporary pastures are used on nearly every hog farm, and are valuable as a supplement to permanent pastures or on farms where there are no permanent pastures. Every barnyard and small lot where hogs are kept should be plowed and seeded at least once a year. These lots are usually well fertilized and produce abundantly.

The most common temporary pastures are rye, oats, wheat, rape, soy beans, and cowpeas. These various pasture plants are grown in practically all parts of the United States. Seeding for temporary pastures should be much heavier than for a grain crop. Rye may be sown in the fall from the 1st of September to December, depending on the locality. In the northern parts of the country it may be grazed until covered by snow or made worthless by freezing. It comes early in the spring and may be grazed until May. If the growth is very rank, it is sometimes advisable to clip it with a mowing machine, setting the cutting bar as high as possible. In the South it may produce good grazing all winter. Winter wheat can be handled in much the same way. In sections where winter oats are grown the crop can be pastured much the same as rye. In the North oats sown in the spring make a good pasture while they last, but the pasture period is short. Rape is often sown with oats in the spring. When rape is sown the Dwarf Essex variety should be used. This crop may be seeded from early spring until summer. When the plants are from 6 to 10 inches high the crop may be grazed quite heavily. It will keep growing and produce good, succulent feed if the season is right. Seed from 4 to 6 pounds to the acre. Cowpeas and soy beans are sown in the spring and are often planted together. In a good growing season very satisfactory results may be expected from these crops.

Dallas grass is a perennial and sweet clover is biennial; the former is grown in the South and the latter in nearly all sections. Both make very satisfactory pastures for hogs. Dallas grass grows well in low, moist lands, makes a good growth in warm weather, and withstands close grazing remarkably well. Sweet clover grows

rapidly in good soils and should be grazed heavily to keep the plants from becoming tough and fibrous.

FENCES

If pastures are utilized to the greatest extent, the various fields and lots must be fenced "hog tight." This is most easily and economically done with woven-wire fencing. When 10-acre or larger fields are fenced, it is best to use a fence 26 inches in height, and it is advisable to place one strand of barbed wire at the bottom of the woven fencing just above the ground. Hogs are more easily kept in large inclosures than in small ones; consequently if the inclosures are small a higher fence will be necessary, say 32 or 36 inches.

Most essential of all in constructing a woven-wire fence is to have good, well-braced corner posts. Probably 90 per cent of the efficiency of a woven-wire fence is in the setting and bracing of the corner posts, making possible the stretching of the wire taut. An animal will soon locate a weak spot in a fence and render it practically useless. Regardless of how taut the fence may be when first constructed, it can not remain that way if the corner posts give in the least. When it is found necessary to construct a temporary fence around a small area, it may be made by using 6-inch fence boards, made into panels, and attaching them to temporary posts or stakes driven into the ground, or by using 26-inch woven-wire fencing which may be unrolled and again rolled after using. The latter method, however, is not very satisfactory, as woven wire is not easily rolled in the field.

MINERAL MIXTURES

Mineral substances in the diet of hogs are just as necessary as the organic matter (protein, fat, and carbohydrates). All vegetable feeds contain certain amounts of sodium, potassium, calcium, magnesium, phosphorus, iron, sulphur, etc. Cereal grains, however, do not furnish these elements in sufficient amounts to satisfy the proper requirements for nutrition and growth. It is necessary, therefore, to supplement the ordinary rations with mineral mixtures.

One of the most essential mineral substances for proper nutrition in animals is ordinary salt (sodium chloride), since this compound enters into the composition of all body tissues, gland secretions, blood, lymph, etc. Phosphates and carbonates of lime and magnesium are necessary for the development and solidity of bones, and must be available in sufficient quantities if normal growth is to be attained. Since the leaves of plants contain more ash than the seeds and stalks, hogs which are pastured on alfalfa, clover, or other grazing crops obtain much of the minerals required; but where pastures are limited or where dry-lot feeding is practiced supplemental mineral feeding is necessary.

At the United States Experiment Farm, Beltsville, Md., the following mineral mixture is giving satisfactory results:

Charcoal.....	75 (3 bushels)	pounds
Raw phosphate rock.....		3 pounds
Salt (sodium chloride).....		6 pounds
Ground limestone (calcium carbonate).....		6 pounds
Flowers of sulphur.....		3 pounds
Copperas (pulverized sulphate of iron).....		1 pound
Glauber salt.....		6 pounds

Where raw phosphate rock and limestone (raw calcium carbonate) can not be procured in finely ground form, the phosphorus and lime may be obtained from raw bone meal and wood ashes.

A mineral mixture should be supplied to hogs in boxes or self-feeders where it will remain dry and be available at all times. A small separate compartment in the self-feeder used for grain feeding makes a convenient combination. Finely granulated or pulverized charcoal is desirable for mixing with the mineral substances and is far superior to soft coal which is frequently used. Neither charcoal nor coal has any food value, however, and it is a mistake to regard charcoal as valuable except for the purpose of keeping the alimentary tract sweet through the absorption of gaseous compounds which are developed during the digestive processes.

WATER

One of the most important matters and one very often neglected is the water supply. Many hogs get their water supply by the herdsman's pouring a quantity of water into a foul, dirty trough twice a day. This system of watering is far from being adequate and should not be followed. Every lot or field in which hogs are kept should be supplied all the year with running water, or some system should be installed whereby the supply is automatic and the hogs have water whenever they want it.

THE FATTENING STOCK

There are two general plans to follow after weaning in getting the hogs ready for market. One is to keep them on a good growing ration until about 60 to 75 days before it is proposed to sell them, feeding them during the last period on a full feed of corn and tankage or fish meal. The other plan is to keep them on full feed at the time until they attain a market weight. The better plan to follow may depend somewhat on market conditions, but more largely on the system of feeding which is best fitted to the particular farm and how it fits into the general farm plan. In either event a pig should never be fed so sparingly that it fails to make gains. The cost per pound of gain must always be considered. If the plan of growing first and fattening later is followed, grain not less than 2 per cent of the body weight of the hog should be fed daily in addition to pasture. Corn or ground barley is the best feed to use. During the fattening period it is advisable to leave the hogs on good, nutritious pasture if available and to give them all the corn or barley they will eat, supplemented by tankage or fish meal. These feeds may be fed either by hand or self-feeder. In either event they should be fed separately. The appetites of individual hogs vary, and when feeds are fed separately the hogs may choose their feeds, but when the feeds are mixed some hogs may not eat as much as they require because they are compelled to eat something not palatable to them. (Fig. 12.)

If the hogs are pushed from weaning time to market, probably the most economical plan is to have them on good pasture with free access to shelled corn and tankage or fish meal in self-feeders. Middlings or shorts of good quality, or old-process linseed meal, may be fed instead of tankage or fish meal. The price should be the controlling factor as to which should be fed. Hand feeding may be

substituted for self-feeders, but it takes more time and generally the gains will not be made so economically.

A successful and economical plan of fattening hogs is to "hog down" the corn, also letting the hogs have access to a good alfalfa or red-clover pasture and tankage or fish meal in a self-feeder. The



FIG. 12.—Self-feeders reduce labor costs in fattening hogs

hogs will harvest all the corn in this way and in addition help build up the fertility of the soil. (Fig. 13.)

Under any plan of feeding, free access to good, pure, water and a mineral mixture containing salt is necessary at all times.

Based on a series of years, hogs weighing from 190 to 235 pounds will command a better price, at least three-fourths of the time, than hogs of lighter or heavier weights. It is impossible to say when



FIG. 13.—An economical and profitable way to harvest the corn crop

fat hogs should be marketed, but a safe plan is to sell when they are at a market weight which commands the best price at the time. No one can foretell future prices; consequently if the producer holds his fat hogs for a better market, he may be sadly disappointed.

FEEDER PIGS

During the last few years there has been an increasing demand for feeder pigs, or pigs weighing generally from 75 to 100 pounds, in some cases up to 120 pounds. This demand comes largely from farmers in the Corn Belt and from men who devote their time to the business of fattening these pigs. Other demands for feeder pigs come from garbage-feeding and serum plants near large cities in different parts of the country.

In the irrigated valleys of the West alfalfa can generally be produced in abundance. In the southern and southeastern sections various good pasture crops for hogs, such as lespedeza, winter oats, rye, wheat, carpet grass, and Bermuda grass can be easily produced. In many of these sections a feed crop necessary to fatten hogs is uncertain, yet it is sufficiently large to be economically used to supplement pastures and make the production of feeder pigs profitable. In view of the demand for feeder pigs at all seasons of the year, the production of these pigs should be given consideration in localities where fattening crops are uncertain. (Fig. 14.)



FIG. 14.—Feeder pigs on alfalfa pasture

SELECTING PIGS FOR BREEDING

Every hog grower should look his pig crop over each year and if possible select a few gilts that will be an improvement in the breeding herd. Sometimes there is an outstanding animal that may be selected soon after weaning, but generally it is best to defer the selections until the pigs are from 5 to 6 months of age. By that time they are so well grown that their faults can be detected. A good, tried brood sow should not be replaced by a gilt unless the change is reasonably sure to make an improvement in the quality of the herd. (Fig. 15.)

If possible the gilts selected for the breeding herd should be placed in a good pasture by themselves. While they should not be too heavily fed, they should be given a liberal ration. Corn should be fed only in limited quantities—from one-fourth to one-third of the total feed. Shorts or middlings, to which is added a little tankage or fish meal, fed either dry or in a thick slop, can constitute, with pasture, a very satisfactory ration. Mineral mixture, salt, and

water should always be kept before them. If after the selection has been made any gilt does not develop satisfactorily she should be discarded from the herd and fattened for market.

THE PUREBRED HOG BUSINESS

A beginner in the hog-raising business should get purebred animals for his foundation, but he should confine his efforts to the raising of market hogs for a few years, or until he knows how to mate animals for good results and how to feed them properly. After he has become more proficient in these lines he may be able to embark in the business of growing purebred hogs with good prospects of success.

The method of handling hogs to be used for breeding purposes is somewhat different from that of fattening them for market. Breeding hogs must be fed with the purpose in mind of growing a good frame that will support the body for several years rather than one

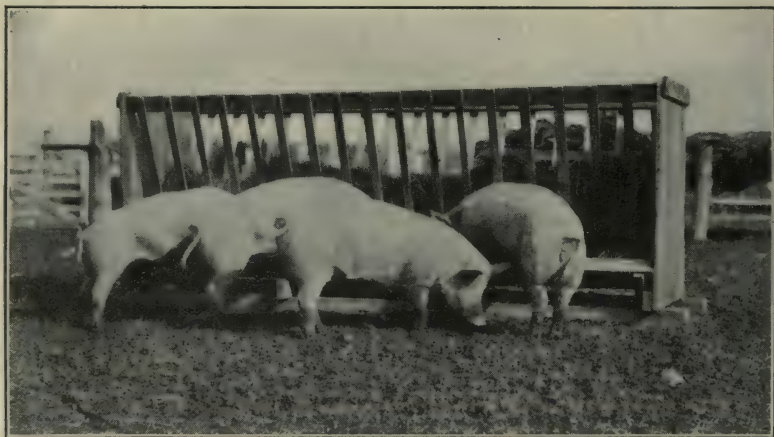


FIG. 15.—Gilts from 5 to 6 months old show qualities as well as defects which indicate their probable value as breeding animals

whose usefulness ends at the age of 8 or 9 months. In order to do this a higher percentage of protein and mineral feeds must be used for the breeding hogs, and they should have the run of a good pasture during the entire time when it is possible to have pastures. The kind of pasture used is of less importance than the fact that pasture is provided. They should have some corn, possibly about one-fourth of the ration, the balance to be made up of shorts or middlings, a little fish meal or tankage, and pasture. Skim milk or buttermilk is recommended if available. Light-weight oats should never be fed, because they are too bulky. Oats may be fed in a self-feeder or scattered thinly on a feeding floor, but should never be fed by pouring them in piles or in a trough. Too many breeders of purebred hogs follow the plan of buying high-priced concentrates and mixed feeds, when feeds that they are growing on their own farms would produce just as good animals at much less cost.

The practice of keeping a registered herd of purebred hogs and selling the offspring for breeding purposes is a branch of the hog

business that may be carried on at a profit, but is often a failure, usually due to unbusinesslike methods. The successful breeder of purebreds must know both the feeding and breeding problems of the business, and in addition must be a good salesman.

KEEPING RECORDS

Some system of identification marks and a book record of them, whereby the pigs of each litter may be known, is always to be advised. If the herd is one from which pedigreed stock for breeding purposes is sold, some system of marking must be followed. The most satisfactory method is by making notches in the ears. In order that no mistake may occur, every pig should be marked at farrowing time. Ear tags of different kinds are used, but they often tear out and the identity of the pig is lost.

If hogs are raised for market only, earmarking the pigs is of great assistance in making selections for the breeding herd. Proper

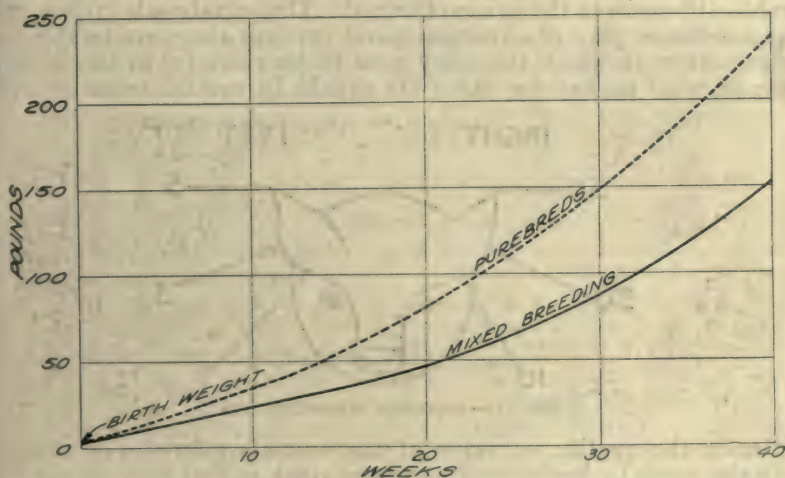


FIG. 16.—Rate of growth of purebred pigs and those of mixed breeding from birth to slaughter. All received substantially the same feed and care

selection can be made only when the dam of the pig is known and her record of performance examined. The date when every sow in the herd is bred should be known and recorded. If this is not done, the herdsman will not know when she is due to farrow and can not intelligently feed and care for her. Such a record can not be made properly unless the individual animals in the herd are earmarked.

Any system of earmarking which is accurate and convenient for the herdsman in the identification of his pigs may be followed. The system indicated in Figure 17 should be satisfactory.

The notches in the ear can be made best with a small, sharp, side-cutting pliers. Little trouble will be experienced in having permanent marks for identification if care is used to include a part of the cartilage of the ear as well as the skin when making the notches. The marks are made best soon after the litter is farrowed, when the wounds heal quickly.

SELLING BREEDING STOCK

The first essential to success in selling breeding stock is in closely culling the herd and offering only animals of merit. The percentage of hogs in the herd that should be culled and fattened for market varies widely. Much depends on the quality of individual animals in the breeding herd and the herdsman's ability to make the best of them by feeding and handling. A herd would be above the average in which 50 per cent or more of the animals should not be culled out and fattened for market.

Two general systems are following in disposing of surplus stock, viz, public and private sale. The public-sale system is quite generally followed and has many advantages. All the stock is sold in one day and the buyer sees what he is buying and names his own price. Among the disadvantages of the public sale are the time and expense in making arrangements, constructing the sale ring, providing the lunch, and the possibility of bad weather, which may make a considerable difference in the prices obtained. The private-sale system calls for a different plan of advertising and requires also considerable correspondence, in which the seller must be very careful in the description of what he has for sale. He should be careful never to over-

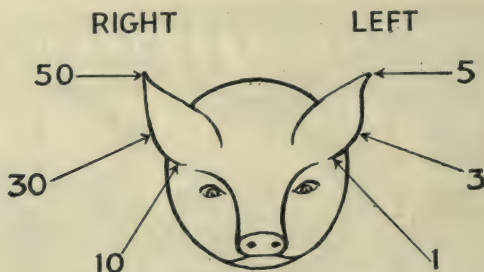


FIG. 17.—Method of earmarking pigs

estimate the quality or value of the animals offered. A common mistake made by breeders of purebred stock is that they do not cultivate the trade of farmers in their own locality. They spend far too much time and money in trying to interest purchasers from a distance. Many bright prospects for success in the purebred business have resulted in failure solely because the breeders have tried to break a record in top prices. Generally the record-breaking price is made because the purchaser gets time in which to make payment. If every transaction in the purebred business were made on a strictly cash basis, the disastrous "booms" would not happen.

SANITATION

Results that may be obtained by following the very best methods of feeding and breeding will be lessened to a great extent unless sanitary conditions on the farm are given careful attention. The greatest losses among hogs are caused by hog cholera. Next in importance is tuberculosis. Other causes are hog "flu" and external and internal parasites. Hog cholera and tuberculosis are germ diseases, and animals contract them only by coming in direct contact with the disease germs. Insanitary hog lots and buildings

may not produce these diseases, but they will have a permanently bad effect on the vitality of the animal. Naturally the animal with the greatest vitality will be in better condition to resist the attack of any disease than will the one low in vitality; hence sanitary conditions in the hog lot may have much to do with losses from either of these diseases.

Farrowing houses and sleeping quarters should be kept thoroughly cleaned and supplied with fresh bedding at frequent intervals. The bedding should be changed whenever it becomes damp and foul. This may be necessary in two days, or it may be two weeks. The floors of the sleeping quarters may become not only foul but dusty. Dust is irritating to the lungs and may convey eggs of parasites as well. For this reason floors should be thoroughly cleaned, swept at least every two or three weeks, and disinfected with a 3 per cent solution of compound cresol (U. S. P.).

Pens, as well as feeding places that are not plowed, should have frequent applications of air-slaked lime, which will aid in the drying of damp places and assist in disinfection. All barnyards and lots, on which hogs are kept for any length of time should be plowed at least twice a year as an aid in the disinfection of the premises. Temporary pasture crops can be grown in these lots, thereby making the plowing profitable in two ways.

HOG WALLOWS

A hog wallow made of concrete and located in a convenient, shady place is a benefit in a hog yard, but a mud wallow made by the hogs rooting a hole in the lot or pasture is a nuisance and should not be allowed to remain. It is impossible to keep the mud wallow in anything resembling a sanitary condition. The hogs will often drink of the water which has become stagnant and foul, and consequently it is a source of danger. The concrete wallow should contain from 4 to 6 inches of water and should be cleaned and re-filled with fresh water at frequent intervals. Crude oil sufficient to form a thin layer on the water should be poured into the wallow about every 10 days to control lice.

SHADE

Hogs suffer greatly from heat and must be provided with shade of some kind. It is best provided by trees, where a sufficient number close enough together are available. The ordinary farrowing house with low ceiling, commonly used in the North, and the box type or A-shaped individual house should not be used for shade. Hogs will seek the shade even though they suffocate. Buildings of the kind stated do not have sufficient air space or circulation. They should be kept closed to prevent hogs from lying in them in hot weather.

A very satisfactory structure for providing shade can be made by constructing a framework about 4 feet in height, using posts, poles, or almost any available material, and covering the top with hay, straw, or weeds to a depth of at least 3 feet. When there is an accumulation of dust under the shelter, wetting the covering by the use of a hose, so that the water drips through, or by water carried and applied, will have the double benefit of laying the dust and cooling the shade. (Fig. 18.)

DISEASES

The two principal diseases from which hogs suffer are hog cholera and tuberculosis, which are discussed briefly below. Hog "flu," or swine influenza, is another disease from which hogs sometimes suffer, the cause of which is unknown. The symptoms are loss of appetite, violent coughing, occasional vomiting, and rise of temperature. The only known treatment is to place them in warm, dry quarters and allow as complete rest as possible, giving them a constant supply of fresh drinking water.

Post-mortem examination is seldom made of the carcasses of animals that die on the farm; consequently the cause of death is not known. Because of the fact that some farm animals have diseases that can be transmitted to hogs, the danger of permitting hogs to eat the carcasses outweighs the food value, and the practice should not be followed.



Fig. 18.—Well-equipped paddocks with artificial and natural shade

HOG CHOLERA

Of all the diseases from which hogs suffer, hog cholera heads the list. It is an infectious disease, and the herd is safe from possible attack only when immunized by the virus-serum treatment. Permanent immunity may be had by giving the pigs this treatment when they are young, which makes the operation less expensive than if done later and shortens the time during which they are subject to infection. If a suspicious ailment occurs, it is best to consult a reliable veterinarian, and if the disease is diagnosed as hog cholera all the uninfected animals should be removed to clean, disinfected quarters and all the hogs in the herd should be immunized with serum and virus as soon as possible. If any of the animals die, the carcasses should be burned to ashes, not buried. Farmers' Bulletin 834 discusses the subject of hog cholera fully.

TUBERCULOSIS

Tuberculosis among hogs in the United States is second only to hog cholera as the cause of losses from disease. The extent to which infection is present in a carcass determines whether a total or partial condemnation of the flesh is necessary or whether it may be safely used as human food.

The source of the disease in hogs is very largely tuberculous cattle. Hogs contract the infection either by drinking unsterilized milk or dairy by-products or by eating grain that has passed undigested through tuberculous cattle. All milk products should be effectively sterilized by cooking before being fed. In order to destroy the disease germs it is necessary to subject the product to the boiling temperature long enough to penetrate the interior of the mass or hold it at a temperature of 140° F. for at least an hour. In some cases the disease is probably transmitted from one hog to another. Fowl tuberculosis is also transmissible to swine. Tuberculosis in hogs can scarcely ever be detected by their appearance, the only reliable known methods of detection being the tuberculin test and slaughter. If hogs sold for slaughter are found to be infected with this disease, it is best to fatten and sell all those remaining in the herd when they are only grades. If purebreds are kept, a reliable veterinarian may be able by means of the tuberculin test to ascertain the diseased animals. All reactors should be slaughtered in an inspected plant. Those failing to react to the test may be retained for breeding purposes, but should be subjected to a retest in from 60 days to 6 months. This subject is discussed in detail in *Farmers' Bulletin* 781.

PARASITES

Hogs of all ages may be affected with external and internal parasites. Death losses seldom occur from these troubles, but indirect losses occur because the vitality is reduced and this condition does not permit of the best and most rapid development. A hog with reduced vitality is naturally more susceptible to attack by any disease. Pigs and young hogs are affected with parasites to a greater extent than older hogs.

INTESTINAL WORMS

Intestinal worms are common among hogs of all ages and are particularly injurious to young, growing pigs. Pigs become infested with these worms by swallowing the worm eggs which are found in the manure of infested hogs or on the soil of pens, yards, and pastures that have been occupied by infested hogs.

Every yard and lot in which hogs run to any considerable extent should be plowed and seeded to a temporary pasture crop at least once every year; twice a year would be better. Mineral mixtures will not prevent worms in hogs, but will have the effect of helping to keep them in good condition. Good, strong, healthy animals have greater resistance to the effect of worms than those in an unthrifty, weak, and generally run-down condition.

Medicinal treatment for worms must be resorted to when methods of prevention have failed or when the pigs have been neglected and

have become unthrifty. Santonin and calomel are very effective in expelling worms from pigs when given in doses of 2 grains each per pig per day for five consecutive days. Results from this daily treatment are better than those obtained from single doses of 10 grains. Santonin, however, is produced in very small quantities at the present time and its cost makes its use almost prohibitive. The most convenient form in which to give santonin is in combination with calomel in No. 0 gelatin capsules. The capsules are administered by means of a capsule gun in connection with a speculum.

Investigations by the Zoological Division, Bureau of Animal Industry, indicate that oil of chenopodium in doses of 1 fluid dram with 2 ounces of castor oil for 100-pound pigs was effectual in destroying more worms than combinations of santonin and calomel. When santonin and calomel are available, however, the results are usually satisfactory, and the easy method of administering the treatment commends it to hog growers in treating young pigs for worms. All worm treatments should be given when the stomach is empty, and during the entire period of treatment the feed should be reduced at least half.

LICE

Hog lice are probably the most common external parasites affecting hogs. They can be found to some extent in most herds at any time. They sustain life by sucking the blood of the animal and are commonly found inside and back of the ears and in the folds on both the front and hind legs. If left alone they thrive and multiply at all seasons of the year. If the herdsman is alert and gives close attention to the application of the right kind of remedies at the right time, lice can be kept down to the point where the damage is negligible.

The common methods of ridding hogs of lice are dipping, spraying, and using hog oilers and medicated hog wallows.

If hogs are to be kept practically free from lice, they must be dipped or thoroughly sprayed every two weeks, or hog oilers must be kept in good condition where the hogs can get at them at any time.

MANGE

Mange is a skin disease caused by small parasites called mites. It is usually first noticed from the formation of crusty scabs around the eyes and ears, from which it spreads to the neck and shoulders, along the back and sides, and finally covers the entire body. The hair is stiff and erect, giving the pig a very unthrifty appearance. Hogs of any age may be affected with mange. Because of the habit that hogs have of lying close together, the disease spreads rapidly from one animal to another. Hogs kept in good, dry, clean, well-bedded quarters are seldom affected with mange. It usually affects hogs that are allowed to sleep in damp, dark sheds or barns or on manure piles or old, damp, straw piles.

The same remedies and treatments recommended for lice should be used for mange. Farmers' Bulletin 1085 treats of the subject of hog lice and mange.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1438

MAKING FERMENTED PICKLES



INFORMATION AND DIRECTIONS for pickling vegetables in brine have been prepared for the use of housewives and producers of pickles, and to meet the needs of extension workers.

Cucumber (salt, sour, sweet, dill, and mixed) pickles and sauerkraut are given most attention. String beans, green tomatoes, chayotes, mango melons, burr gherkins, cauliflower, corn on the cob, and some fruits, such as peaches and pears, are mentioned.

Although intended mainly for guidance in putting up pickles on a small scale in the home, this bulletin may be used also in preparing large quantities on a commercial or semicommercial scale.

This bulletin is a revision of, and supersedes, Farmers' Bulletin 1159.

MAKING FERMENTED PICKLES

By EDWIN LEFEVRE, *Scientific Assistant, Microbiological Laboratory,
Bureau of Chemistry*

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ALTHOUGH excellent pickles can be bought on the market at all seasons of the year, many housewives prefer to make their own, particularly when their home gardens afford a plentiful supply of cucumbers.

Brining is a good way to save surplus cucumbers that can not be used or readily sold in the fresh state. Instead of letting them go to waste it is very easy to cure them, after which they may be held as long as desired or until they can be sold to advantage, either in local markets or to pickle manufacturers. Thus growers are protected against loss by overproduction or from inability to speedily market a perishable crop, and the pickle market receives the benefit of a steady supply.

HOW BRINING PRESERVES VEGETABLES

When vegetables are placed in brine the juices and soluble material contained in them are drawn out by the force known as osmosis.

The fermentable sugar present in all fruits and vegetables, which is one of the soluble substances extracted by osmotic action, serves as food for the lactic-acid bacteria which break it down into lactic acid and certain volatile acids. In some vegetables, like cucumbers and cabbage, where the supply of sugar is ample and other conditions are favorable to the growth of the lactic bacteria, a decided acid formation takes place, constituting a distinct fermentation. The acid brine thus formed acts upon the vegetable tissues, bringing about the changes in color, taste, and texture which mark the pickled state.

As a rule, a solution of salt is used, although some vegetables quickly give up enough moisture to convert dry salt into brine. Salt also hardens or makes firm the vegetables placed in brine and checks the action of organisms which might otherwise destroy the plant tissues.

Cabbage is well preserved in its own brine in the form of sauerkraut. Other vegetables and some fruits may, under certain conditions, be economically preserved by brining. As a rule, however, canning is preferable for these products, because food values and natural flavors are better preserved by that method. Lack of time, a shortage of cans, or an oversupply of raw material may justify the preservation of vegetables other than cucumbers and cabbage by curing in brine.

EQUIPMENT FOR BRINING AND PICKLING

Stone jars are the most convenient and desirable receptacles (fig. 1) for making small quantities of pickles. Stoneware is much more easily kept clean and absorbs objectionable odors and flavors to a smaller extent than wood. Straight-side, open-top jars, which come in practically all sizes, from 1 to 20 gallons, are best for this purpose. Those used for the directions given in this bulletin are 4-gallon jars which hold about 12 pounds (one-fourth bushel) of cucumbers.

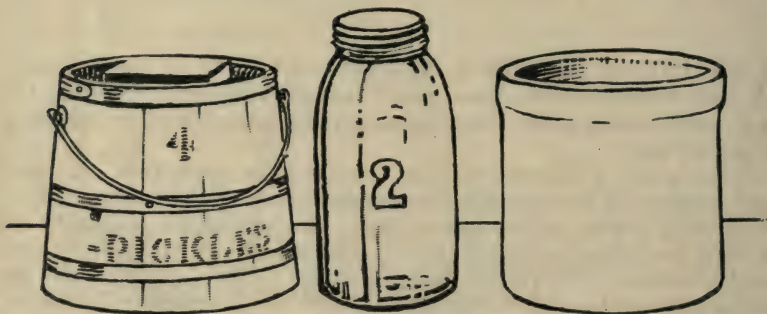


FIG. 1.—Some suitable containers for home-brined products

If only very small quantities of pickles are put up, wide-mouth bottles or glass jars will do.

Water-tight kegs or barrels are best for making larger quantities of pickles. Those used for the directions given in this bulletin are barrels holding from 40 to 45 gallons. They must first be washed, or possibly charred, to remove all undesirable odors and flavors. Undesirable flavors may be removed by using solutions of potash or soda lye. A strong solution of lye should remain in the barrel for several days, after which the barrel should be thoroughly soaked and washed with hot water until the lye is removed.

Boards about an inch thick make the best covers. These may be of any kind of wood, except yellow or pitch pine, which would give the pickles an undesirable flavor. They should be from 1 to 2 inches less in diameter than the inside of the jar or barrel, so that they may be easily removed. Dipping the covers in paraffin and then burning them over with a flame fills the pores of the wood, thus making it comparatively easy to keep them clean. Heavy plates of suitable size may be used instead of boards as covers for small containers.

A clean white cloth is often needed to cover the material in the jar or barrel. Two or three thicknesses of cheesecloth or muslin, cut in circular form, and about 6 inches larger in diameter than the inside of the receptacle, makes a suitable covering. Sometimes grape, beet, or cabbage leaves are used for this purpose. Grape leaves are a good covering for dill pickles, and cabbage leaves for sauerkraut.

In addition to the jars, crocks, or kegs in which the pickles are made, 2-quart glass jars are needed for packing the finished product. If corks are used for sealing such containers, they should first be dipped in hot paraffin.

When vegetables which have been fermented in a weak brine are to be kept for any length of time, air must be excluded from them. This may be done by sealing the containers with paraffin, beeswax, or oil. Paraffin, the cheapest and probably the best of these three substances, is easily handled and readily separated from the pickles when they are removed from the containers. To remove any dirt, the paraffin should be heated and strained through several thicknesses of cheesecloth. Thus the paraffin may be used over and over again. The clean paraffin is melted and poured over the surface of the pickles in quantities sufficient to make, when hardened, a solid coating about half an inch thick. Where there are vermin, lids should be placed over the paraffin in jars and other covers should be placed over the paraffin in kegs. If applied before active fermentation has stopped, the seal may be broken by the formation of gas below the layer, making it necessary to remove the paraffin, heat it again, and once more pour it over the surface.

In many cases a safer and better plan for preserving vegetables fermented in a weak brine is to transfer the pickled product to glass jars as soon as fermentation is completed and seal tightly.

Almost anything which furnishes the required pressure will serve as a weight to hold the mass down in a jar or keg. Clean stones (except limestone) and bricks are recommended.

A pair of kitchen scales and suitable vessels for determining liquid measure are, of course, essential.

The salinometer, an instrument for measuring the salt strength of a brine, is very useful, although not absolutely necessary, in brining (fig. 2). By following the directions given here it will be possible to make brines of the required strength without the use of this instrument. Results may be readily checked, however, and any changes in brine strength which occur from time to time may be detected by the use of the salinometer.

The salinometer scale is graduated into 100 degrees, which indicate the range of salt concentration between 0°, the reading for pure water at 60° F., and 100°, which indicates a saturated salt solution



FIG. 2.—Salinometer

(26½ per cent). Table 1 (page 14) shows the relation between salinometer readings and salt percentages.

Salinometers are sold for about \$1 each by firms dealing in chemical apparatus and supplies.

A sugar hydrometer is very useful in all canning and pickling work. Either the Brix or Balling scale may be used. Both read directly in percentages of sugar in a pure sugar solution. A Balling hydrometer, graduated from 0° to 70°, is a convenient instrument for the tests indicated in this bulletin.

SUPPLIES FOR BRINING AND PICKLING

SALT

Fine table salt is not necessary. What is known as common fine salt, or even coarser grades, may be used. Caked or lumpy salt can not be equally distributed. Salt to which anything has been added to prevent caking is not recommended for pickling and brining. Alkaline impurities in the salt are especially objectionable. Any noncaking salt which contains less than 1 per cent of the carbonates or bicarbonates of sodium, calcium, or magnesium may be used for this purpose.

VINEGAR

A good, clear vinegar of 40 to 60 grain strength (4 to 6 per cent acetic acid) is required in making sour, sweet, and mixed pickles, and is sometimes used for dill pickles. Many pickle manufacturers prefer distilled vinegar, as it is colorless and free from sediment. If fruit vinegars are used they should first be filtered to remove all sediment.

SUGAR

Granulated sugar should be used in making sweet pickles. The quantity of sugar required for each gallon of vinegar in making sweet liquors is shown in Table 3 (p. 15).

SPICES

Spices are used to some extent in making nearly all kinds of pickles, but chiefly for sweet, mixed, and dill pickles. Various combinations are used, depending on the kind of pickles to be made and the flavor desired.

Peppers (black and cayenne), cloves, cinnamon, celery seed, caraway, dill herb, mustard (yellow), allspice, cardamom, bay leaves, coriander, turmeric, and mace, are the principal whole spices for this purpose. Ginger and horse-radish root are used sometimes. All of these spices may be purchased in bulk and mixed as desired. Mixed whole spices, specially prepared for pickling purposes, sold in the stores, are, as a rule, satisfactory. Care should be taken to see that they are of proper strength.

Oil spices may be desirable under some circumstances, but their effect is not so lasting as that of the whole spices.

Turmeric has been much used in both the commercial and household preparation of pickles. While some of its qualities entitle it

to be classed among the spices, it does not rank in importance as such with the others named. It is employed largely because of its supposed effect on the color of pickles, which is probably overestimated.

Dill herb is practically always used with cucumbers when they are fermented in a weak brine and often with other vegetables fermented in this way. It gives the pickle a distinct flavor which is very popular. The dill herb, a native of southern Europe, can be grown in nearly all parts of the United States and usually is obtainable in the markets of the larger cities. While the entire stalk of the dill herb is of value for flavoring, the seeds are best suited for imparting the desired flavor. For this reason the crop should be harvested only after the seeds have become fully mature but are not so ripe that they fall off. The herb may be used green, dried, or brined. When green or brined dill is used, twice as much by weight as would be required if the dried herb were used is taken. Dill retains its flavor for a long time when brined. To preserve it in this way it should be packed in a 60° brine, or in an 80° brine if it is to be kept for a long time. Dill brine is as good as the herb for flavoring.

CUCUMBER PICKLES

Because of their shape, firmness, or keeping quality some varieties of cucumbers are better adapted for making pickles than others. Among the best of the pickling varieties are the Chicago Pickling, Boston Pickling, and Snow's Perfection. Cucumbers of practically all varieties, sizes, and shapes, however, make good pickles.¹

Cucumbers to be pickled should retain from one-eighth to one-fourth inch of their stems, and they should not be bruised. If dirty they should be washed before brining. They should be placed in brine not later than 24 hours after they have been gathered.

Cucumbers contain approximately 90 per cent of water. As this large water content reduces materially the salt concentration of any brine in which they are fermented, it is necessary to add an excess of salt at the beginning of a fermentation in the proportion of 1 pound for every 10 pounds of cucumbers.

The active stage of cucumber fermentation continues for 10 to 30 days, depending largely on the temperature at which it is conducted. The most favorable temperature is 86° F.

Practically all the sugar withdrawn from the cucumbers is utilized during the stage of active fermentation, at the end of which the brine reaches its highest degree of acidity. During this period the salt concentration should not be materially increased; for, although the lactic bacteria are fairly tolerant of salt, there is a limit to their tolerance. The addition of a large quantity of salt at this time would reduce their acid-forming power just when this is essential to a successful fermentation. Salt, therefore, should be added gradually over a period of weeks.

SALT PICKLES

Salt pickles, or salt stock, are made by curing cucumbers in a brine which should contain not less than 9.5 per cent of salt (approximately 36° on the salinometer scale) at the start. Not only must the

¹ Information on the cultivation of cucumbers, and the diseases and enemies which attack them, may be obtained from the United States Department of Agriculture.

brine be kept at this strength, but salt should be added until it has a concentration of about 15 per cent (60° on the salinometer scale). If well covered with a brine of this strength, the surface of which is kept clean, pickles will keep indefinitely.

Proper curing of cucumbers requires from six weeks to two months, or possibly longer, according to the temperature at which the process is carried out and the size and variety of the cucumbers. Attempts to use short cuts or to make pickles overnight, as is sometimes advised, are based on a mistaken idea of what really constitutes a pickle.

Curing of cucumbers is marked by an increased firmness, a greater degree of translucency, and a change in color from pale green to dark or olive green. These changes are uniform throughout the perfectly cured specimen. So long as any portion of a pickle is whitish or opaque it is not perfectly cured.

After proper processing in water, salt pickles may be eaten as such or they may be converted into sour pickles (p. 7), sweet pickles (p. 8), or mixed pickles (p. 10).

SMALL QUANTITIES

Pack the cucumbers in a 4-gallon jar and cover with 6 quarts of a 10 per cent brine (40° on salinometer scale). At the time of making up the brine, or not later than the following day, add more salt at the rate of 1 pound for every 10 pounds of cucumbers used—in this case 1 pound and 3 ounces. This is necessary to maintain the strength of the brine.

Cover with a round board or plate that will go inside the jar, and on top of this place a weight heavy enough to keep the cucumbers well below the surface of the brine.

At the end of the first week, and at the end of each succeeding week for five weeks, add one-fourth pound of salt. In adding salt always place it on the cover. If it is added directly to the brine, it may sink, as a result of which the salt solution at the bottom will be very strong, while that near the surface may be so weak that the pickles will spoil.

A scum, made up usually of wild yeasts and molds, forms on the surface. As this may prove injurious by destroying the acidity of the brine, remove it by skimming.

LARGE QUANTITIES

Put into a barrel 5 to 6 inches of a 40° brine (Table 1, p. 14) and add 1 quart of good vinegar. In this brine place the cucumbers as they are gathered. Weigh the cucumbers each time before they are added. Put a loose-fitting wooden cover over the cucumbers and weight it down with a stone heavy enough to bring the brine over the cover. After the cover and stone have been replaced add to the brine over the cover 1 pound of salt for every 10 pounds of cucumbers.

Unless the cucumbers are added too rapidly, it will be unnecessary to add more brine, for when a sufficient weight is maintained on the cover the cucumbers make their own brine. If, however, the cucumbers are added rapidly, or if the barrel is filled at once, more brine may be required. In such a case, add enough of the 40° brine to cover the cucumbers.

When the barrel is full, add 3 pounds of salt each week for five weeks (15 pounds to a 45-gallon barrel). In adding the salt, place it on the cover. Added in this way it goes into solution slowly, insuring a brine of uniform strength throughout and a gradually increasing salt concentration. Thus, shriveling of the pickles is prevented to a great extent and the growth and activity of the lactic bacteria are not seriously checked.

Stirring or agitation of the brine may be harmful for the reason that the introduction of air bubbles is conducive to the growth of spoilage bacteria.

From time to time remove the scum which forms on the surface.

Where cucumbers are grown extensively for the production of pickles, curing is done in large tanks at salting stations. While it involves certain details of procedure not required in barrel quantities, this method of curing is essentially the same.

PROCESSING

After being cured in brine, pickles must receive a processing in water to remove the excess of salt. If they are to be used as salt pickles, only a partial processing is required. If, however, they are to be made into sour, sweet, or mixed pickles, the salt should be largely, but not completely, removed. Pickles keep better when the salt is not entirely soaked out.

Under factory conditions, processing is accomplished by placing the pickles in tanks, which are then filled with water and subjected to a current of steam, the pickles being agitated meanwhile. In most homes, however, the equipment for such treatment is not available.

The best that can be done in the home is to place the pickles in a suitable vessel, cover them with water, and heat them slowly to about 120° F., at which temperature they should be held for from 10 to 12 hours, being stirred frequently. The water is then poured off, and the process is repeated, if necessary, until the pickles have only a slightly salty taste.

SORTING

After processing, the pickles should be sorted. To secure the most attractive product, pickles should be as nearly as possible of uniform size. At least three sizes are recognized—small (2 to 3 inches long), medium (3 to 4 inches long), and large (4 inches or longer). Only the small sizes are selected for bottling. Fairly small and medium-large cucumbers are well adapted to the making of sweet pickles. The larger sizes may be used for sour and dill pickles. Imperfectly formed pickles, the so-called crooks and nubs, can be cut up and added to mixed pickles or other combinations of which cucumbers form a part. The number of pickles of various sizes required to make a gallon is shown in Table 4, page 16.

SOUR PICKLES

After pickles have been processed sufficiently, drain them well and cover them at once with vinegar. A 45 or 50 grain vinegar usually gives all the sourness that is desirable. If, however, very sour pickles are preferred, it would be well to use at first a 45-grain vinegar, and after a week or 10 days transfer the pickles to a vinegar of the

strength desired. As the first vinegar used will in all cases be greatly reduced in strength by dilution with the brine contained in the pickles, it will be necessary to renew the vinegar after a few weeks. If this is not done and the pickles are held for any length of time they may spoil.

The best containers for sour pickles are stone jars, or, for large quantities, kegs or barrels. Covered with a vinegar of the proper strength, pickles should keep indefinitely.

SWEET PICKLES

Cover the cured and processed cucumbers with a sweet liquor made by dissolving sugar in vinegar, usually with the addition of spices. Depending upon the degree of sweetness desired, the quantity of sugar may vary from 4 to 10 pounds to the gallon of vinegar, 6 pounds to the gallon usually giving satisfactory results. The chief difficulty in making sweet pickles is their tendency to become shriveled and tough, which increases with the sugar concentration of the liquor. This danger can usually be avoided by covering the pickles first with a plain 45 to 50 grain vinegar. After one week discard this vinegar, which in all probability has become greatly reduced in strength, and cover with a liquor made by adding 4 pounds of sugar to the gallon of vinegar. It is very important that the acidity of the liquor used on pickles be kept as high as possible. A decrease in acidity much below a 30-grain strength may permit the growth of yeasts, with resulting fermentation and spoilage.

If a liquor containing more than 4 pounds of sugar to the gallon is desired, it would be best not to exceed that quantity at first, but gradually add sugar until the desired concentration is obtained. A sugar hydrometer readily and accurately indicates the sugar concentration (p. 4). A reading of 42° (Brix or Balling) would indicate a concentration of approximately 6 pounds of sugar to the gallon of vinegar. (Table 3, p. 15.)

Spices are practically always added in making sweet pickles. The effect of too much spice, especially the stronger kinds, like peppers and cloves, however, is injurious. One ounce of whole mixed spices to 4 gallons of pickles is enough. As spices may cause cloudiness of the vinegar, they should be removed after the desired flavor has been obtained. Heating is an aid to a better utilization of the spice. Add the required quantity of spice, in a cheesecloth bag, to the vinegar and hold at the boiling point for not longer than half an hour. Heating too long causes the vinegar to darken. If considered desirable, add sugar at this time, and pour at once over the pickles.

If the pickles are to be packed in bottles or jars, after such preliminary treatment as may be required, transfer them to these containers and cover them with a liquor made as desired.

DILL PICKLES

The method for making dill pickles differs from that for making salt pickles in two important particulars. A much weaker brine is used, and spices, chiefly dill, are added.

Because of the weaker salt concentration, a much more rapid curing takes place. As a result they can be made ready for use in about half the time required for ordinary brined pickles. This shortening

of the period of preparation, however, is gained at the expense of the keeping quality of the product. For this reason it is necessary to resort to measures which will prevent spoilage.

SMALL QUANTITIES

Place in the bottom of the jar a layer of dill and one-half ounce of mixed spice. Then fill the jar, to within 2 or 3 inches of the top, with washed cucumbers of as nearly the same size as practicable. Add another half ounce of spice and layer of dill. It is a good plan to place over the top a layer of grape leaves. In fact, it would be well to place these at both the bottom and top. They make a very suitable covering and have a greening effect on the pickles.

Pour over the pickles a brine made as follows: Salt, 1 pound; vinegar, 1 pint; water, 2 gallons. Never use a hot brine at the beginning of a fermentation. The chances are that it would kill the organisms present, thus preventing fermentation.

Cover with a board cover or plate with sufficient weight on top to hold the cucumbers well below the brine.

If the cucumbers are packed at a temperature around 86° F., an active fermentation will at once set in. This should be completed in 10 days to 2 weeks, if a temperature of about 86° F. is maintained. The scum which soon forms on the surface and which consists usually of wild yeasts, but often contains molds and bacteria, should be skimmed off.

After active fermentation has stopped, it is necessary to protect the pickles against spoilage. This may be done in one of two ways:

(1) Cover with a layer of paraffin. This should be poured while hot over the surface of the brine or as much of it as is exposed around the edges of the board cover. When cooled this forms a solid coating which effectually seals the pickles.

(2) Seal the pickles in glass jars or cans. As soon as they are sufficiently cured, which may be determined by their agreeable flavor and dark-green color, transfer them to glass jars, and fill either with their own brine or with a fresh brine made as directed. Add a small quantity of dill and spice. Bring the brine to a boil, and, after cooling to about 160° F., pour it over the pickles, filling the jars full. Seal the jars tight.

The plan of preserving dill pickles by sealing in jars has the merit of permitting the use of a small quantity without the necessity of opening and resealing a large bulk, as is the case when pickles are packed in large containers and sealed with paraffin.

LARGE QUANTITIES

Fill a barrel with cucumbers. Add 6 to 8 pounds of green or brined dill, or half that quantity of dry dill, and 1 quart of mixed spices. If brined dill is used, it is well to add about 2 quarts of the dill brine. The dill and spices should be evenly distributed at the bottom, middle, and top of the barrel. Also add 1 gallon of good vinegar.²

² This addition of vinegar is not essential, and many prefer not to use it. In the proportion indicated, however, it is favorable to the growth of the lactic bacteria and helps to prevent the growth of spoilage organisms. Its use, therefore, is to be regarded with favor. Some prefer to omit the mixed spices for the reason that they interfere with the distinctive flavor of the dill herb.

Head up tight and, through a hole bored in the head, fill the barrel with a brine made in the proportion of one-half pound of salt to a gallon of water. Add brine until it flows over the head and is level with the top of the chime. Maintain this level by adding brine from time to time. Remove the scum which soon forms on the surface.

During the period of active fermentation, keep the barrel in a warm place and leave the hole in the head open to allow gas to escape. When active fermentation is over, as indicated by the cessation of bubbling and frothing on the surface, the barrel may be plugged tight and placed in storage, preferably in a cool place. Leakage and other conditions may cause the brine in a barrel of pickles to recede at any time. The barrels should be inspected occasionally, and more brine added if necessary. Pickles put up in this way should be ready for use within about six weeks.

When pickles are to be held in storage a long time, a 28° brine, made by adding 10 ounces of salt to a gallon of water, should be used. Pickles packed in a brine of this strength will keep a year, if the barrels are kept filled and in a cool place. The important factor in preserving pickles put up in a weak brine, such as is ordinarily used for dill pickles, is the exclusion of air. When put up in tight barrels this is accomplished by keeping the barrels entirely filled with brine.

MIXED PICKLES

Onions, cauliflower, green peppers, tomatoes, and beans, as well as cucumbers, are used for making mixed pickles. All vegetables should first be cured in brine.

For making mixed pickles, very small vegetables are much to be preferred. If larger ones must be used, first cut them into pieces of a desirable and uniform shape and size. Place in the bottom of each wide-mouth bottle or jar a little mixed-spice. In filling the bottle arrange the various kinds of pickles in as neat and orderly a manner as possible. The appearance of the finished product depends largely upon the manner in which they are packed in the bottle. Do not completely fill the bottles.

If sour pickles are desired, fill the bottles completely with a 45-grain vinegar. If sweet ones are wanted, fill with a liquor made by dissolving 4 to 6 pounds of sugar in a gallon of vinegar.

- Seal tight, and label properly.

SAUERKRAUT

For making sauerkraut in the home, 4 or 6 gallon stone jars are considered the best containers, unless large quantities are desired, in which case kegs or barrels may be used.

Select only mature, sound heads of cabbage. After removing all decayed or dirty leaves, quarter the heads and slice off the core portion. For shredding, one of the hand-shredding machines which can be obtained on the market is much the best, although an ordinary slaw cutter or a large knife will do.

In making sauerkraut the fermentation is carried out in a brine made from the juice of the cabbage which is drawn out by the salt.

One pound of salt for every 40 pounds of cabbage makes the proper strength of brine to produce the best results. The salt may be distributed as the cabbage is packed in the jar or it may be mixed with the shredded cabbage before being packed. The distribution of 2 ounces of salt with every 5 pounds of cabbage probably is the best way to get an even distribution.

Pack the cabbage firmly, but not too tightly, in the jar or keg. When full, cover with a clean cloth and a board or plate. On the cover place a weight heavy enough to cause the brine to come up to the cover.

If the jar is kept at a temperature of about 86° F., fermentation will start promptly. A scum soon forms on the surface of the brine. As this scum tends to destroy the acidity and may affect the cabbage, it should be skimmed off from time to time.

If kept at 86° F., the fermentation should be completed in six to eight days.

A well-fermented sauerkraut should show a normal acidity of approximately +20, or a lactic acid percentage of 1.8 (p. 16).

After fermentation is complete, set the sauerkraut in a cool place. If the cabbage is fermented late in the fall, or if it can be stored in a very cool place, it may not be necessary to do more than keep the surface skimmed and protected from insects, etc.; otherwise it will be necessary to resort to one of the following measures to prevent spoilage:

(1) Pour a layer of hot paraffin over the surface, or as much of it as is exposed around the cover. Properly applied to a clean surface, this effectually seals the jar and protects the contents from contamination.

(2) After the fermentation is complete, pack the sauerkraut in glass jars, adding enough of the "kraut" brine, or a weak brine made by adding an ounce of salt to a quart of water, to completely fill the jars. Seal the jars tight, and set them away in a cool place.

The second method is much to be preferred to the first. Sauerkraut properly fermented and stored in this way has kept throughout a season in good condition. Placing the jars before sealing in a water bath and heating until the center of the jar shows a temperature of about 160° F. gives an additional assurance of good-keeping quality of the "kraut."

In the commercial canning of sauerkraut, where conditions and length of storage can not be controlled, heat must always be used.

FERMENTATION AND SALTING OF VEGETABLES OTHER THAN CUCUMBERS AND CABBAGE

There are three methods of preserving vegetables by the use of salt:

FERMENTATION IN AN ADDED BRINE

Experiments have shown that string beans, green tomatoes, beets, chayotes, mango melons, burr gherkins, cauliflower, and corn (on cob) may be well preserved in a 10 per cent brine (40° on the salinometer scale) for several months. Peppers and onions are better preserved in an 80° brine. The brine must be maintained at its

original strength by the addition of salt, and the surface of the brine must be kept free from scum. Some of the vegetables listed, notably string beans and green tomatoes, are well adapted to fermentation in a weak brine (5 per cent salt), in which case dill and other spices may be added. The general directions given for dill pickles (p. 8) should be followed.

FERMENTATION IN BRINE PRODUCED BY DRY SALTING

This method, of course, can be used only for vegetables which contain enough water to make their own brine. String beans, if young and tender, may be preserved in this way. Remove tips and strings, and, if the pods are large, break them in two. Older beans, and doubtless other vegetables, could be preserved by this method if first shredded in the same manner as cabbage (p. 10). Use salt equal to 3 per cent of the weight of the vegetables (1 ounce salt to about 2 pounds vegetables).

SALTING WITHOUT FERMENTATION

Enough salt to prevent all bacterial action must be added. Wash and weigh the vegetables. Mix with them thoroughly one-fourth their weight of salt. If after the addition of pressure there is not enough brine to cover the product, add brine made by dissolving 1 pound of salt in 2 quarts of water. As soon as bubbling ceases, protect the surface by covering with paraffin. This method is especially well adapted to vegetables in which the sugar content is too low to produce a successful fermentation, such as chard, spinach, and dandelions. Corn can also be well preserved in this way. Husk it and remove the silk. Cook it in boiling water for 10 minutes, to set the milk. Then cut the corn from the cob with a sharp knife, weigh it, and pack it in layers, with one-fourth its weight of fine salt.

The methods of preservation outlined are not limited to vegetables. Solid fruits, like clingstone peaches and Kieffer pears, can be preserved in an 80° brine for as long as six months. After the salt has been soaked out, they may be worked up into desirable products by the use of spices, vinegar, sugar, etc. Soft fruits, like Elberta peaches and Bartlett pears, are best preserved in weak vinegar (2 per cent acetic acid).³

CAUSES OF FAILURE

SOFT OR SLIPPERY PICKLES

A soft or slippery condition, one of the most common forms of spoilage in making pickles, is the result of bacterial action. It always occurs when pickles are exposed above the brine and very often when the brine is too weak to prevent the growth of spoilage organisms. To prevent it keep the pickles well below the brine and the brine at the proper strength. To keep pickles for more than a

³ Report of an investigation in the Bureau of Chemistry on the utilization of brined products, by Rhea C. Scott, 1919.

very few weeks a brine should contain 10 per cent of salt. Once pickles have become soft or slippery as a result of bacterial action no treatment will restore them to a normal condition.

HOLLOW PICKLES

Hollow pickles may occur during the process of curing. This condition, however, does not mean a total loss, for hollow pickles may be utilized in making mixed pickles or certain forms of relish. While there are good reasons to believe that hollow pickles are the result of a faulty development or nutrition of the cucumber, there is also a strong probability that incorrect methods may contribute to their formation. One of these is allowing too long a time to intervene between gathering and brining. This period should not exceed 24 hours.

Hollow pickles frequently become floaters. Sound cucumbers properly cured do not float, but any condition which operates to lower their relative weight, such as gaseous distention, may cause them to rise to the surface.

EFFECT OF HARD WATER

So-called hard waters should not be used in making a brine. The presence of large quantities of calcium salts and possibly other salts found in many natural waters may prevent the proper acid formation, thus interfering with normal curing. The addition of a small quantity of vinegar serves to overcome alkalinity when hard water must be used. If present in any appreciable quantity, iron is objectionable, causing a blackening of the pickles under some conditions.

SHRIVELING

Shriveling of pickles often occurs when they have been placed at once in very strong salt or sugar solutions, or even in very strong vinegars. For this reason avoid such solutions so far as possible. When a strong solution is desirable the pickles should first be given a preliminary treatment in a weaker solution. This difficulty is most often encountered in making sweet pickles. The presence of sugar in high concentrations is certain to cause shriveling unless precautions are taken (p. 8).

EFFECT OF TOO MUCH SALT ON SAUERKRAUT

Perhaps the most common cause of failure in making sauerkraut is the use of too much salt. The proper quantity is $2\frac{1}{2}$ per cent by weight of the cabbage packed. When cabbage is to be fermented in very warm weather it may be well to use a little more salt. As a rule, however, this should not exceed 3 per cent. In applying the salt see that it is evenly distributed. The red streaks which are sometimes seen in sauerkraut are believed to be due to uneven distribution of salt.

EFFECT OF SCUM

Spoilage of the top layers of vegetables fermented in brine is sure to occur unless the scum which forms on the surface is frequently removed. This scum is made up of wild yeasts, molds, and bacteria,

which, if allowed to remain, attack and break down the vegetables beneath. They may also weaken the acidity of the brine, in which way they may cause spoilage. The fact that the top layers have spoiled, does not necessarily mean, however, that all in the container are spoiled. The molds and other organisms which cause the spoilage do not quickly get down to the lower layers. The part found in good condition often may be saved by carefully removing the spoiled part from the top, adding a little fresh brine, and pouring hot paraffin over the surface.

EFFECT OF TEMPERATURE

Temperature has an important bearing on the success of a lactic fermentation. The bacteria which are essential in the fermentation of vegetable foods are most active at a temperature of approximately 86° F., and as the temperature falls below this point their activity correspondingly diminishes. It is essential, therefore, that the foods be kept as close as possible to 86° F. at the start and during the active stages of a fermentation. This is especially important in the production of sauerkraut, which is often made in the late fall or winter. The fermentation may be greatly retarded or even stopped by too low a temperature.

After the active stages of a fermentation have passed, store the food in a cool place. Low temperatures are always an aid in the preservation of food products.

COLORING AND HARDENING AGENTS

To make what is thought to be a better looking product, it is the practice in some households to "green" pickles by heating them with vinegar in a copper vessel. Experiments have shown that in this treatment copper acetate is formed, and that the pickles take up very appreciable quantities of it. *Copper acetate is poisonous.*

By a ruling of the Secretary of Agriculture, made July 12, 1912, foods greened with copper salts, all of which are poisonous, will be regarded as adulterated.

Alum is often used for the purpose presumably of making pickles firm. The use of alum in connection with food products is of doubtful expediency, to say the least. If the right methods are followed in pickling, the salt and acids in the brine will give the desired firmness. The use of alum, or any other hardening agent, is unnecessary.

TABLES AND TESTS

TABLE 1.—Salt percentages, corresponding salinometer readings, and quantity of salt required to make 6 quarts of brine

Salt in solution	Salino-meter reading	Salt in 6 quarts of finished brine	Salt in solution	Salino-meter reading	Salt in 6 quarts of finished brine
<i>Per cent</i>	<i>Degrees</i>	<i>Ounces</i>	<i>Per cent</i>	<i>Degrees</i>	<i>Ounces</i>
1.06	4	2	8.48	32	18
2.12	8	4½	9.54	36	20
3.18	12	6½	10.6	40	22½
4.24	16	8½	15.9	60	35
5.3	20	11	21.2	80	48
6.36	24	13	26.5	100	64
7.42	28	14½			

The figures given in the first two columns of Table 1 are correct. Those in the last column are correct within the possibilities of ordinary household methods. To make up a brine from this table, the required quantity of salt is dissolved in a smaller volume of water and water is added to make up as nearly as possible to the required 6 quarts.

One pound of salt dissolved in 9 pints of water makes a solution with a salinometer reading of 40°, or approximately a 10 per cent brine. In a brine of this strength, fermentation proceeds somewhat slowly. Pickles kept in a brine maintained at this strength will not spoil. One-half pound of salt dissolved in 9 pints of water makes approximately a 5 per cent brine, with a salinometer reading of 20°. A brine of this strength permits a rapid fermentation, but vegetables kept in such a brine will spoil within a few weeks if air is not excluded.

A brine in which a fresh egg just floats is approximately a 10 per cent solution.

Fermentation takes place fairly well in brines of 40° strength, and will, to some extent at least, up to 60°. At 80° all fermentation stops.

The volume of brine necessary to cover vegetables is about half the volume of the material to be fermented. For example, if a 5-gallon keg is to be packed, 2½ gallons of brine is required.

TABLE 2.—Freezing point of brine at different salt concentrations

Salt	Salinometer reading	Freezing temperature
<i>Per cent</i>	<i>Degrees</i>	<i>° F.</i>
5	20	25.2
10	40	18.7
15	60	12.2
20	80	6.1
25	100	0.5

TABLE 3.—Density of sugar sirup

Density	Quantity of sugar for each gallon of water ¹		Density	Quantity of sugar for each gallon of water ¹	
<i>Degrees Brix or Balling</i>	<i>Lbs.</i>	<i>Ozs.</i>	<i>Degrees Brix or Balling</i>	<i>Lbs.</i>	<i>Ozs.</i>
5		7	35	4	7.75
10		14.8	40	5	8.75
15	1	7.5	45	6	13
20	1	14.75	50	8	5.25
25	2	12.5	55	10	4
30	3	9	60	12	8

¹ When vinegar is used, the equivalent sugar hydrometer reading would be about 2 degrees higher than that indicated in the table.

TABLE 4.—*Number of cucumbers of various sizes required to make a gallon of pickles*

Size	Variety	Number to a gallon
1 to 2 inches long.....	Gherkins ¹	250 to 650
2 to 3 inches long.....	Small pickles.....	130 to 250
3 to 4 inches long.....	Medium pickles.....	40 to 130
4 inches and longer.....	Large pickles.....	12 to 40

¹ Small pickles are usually designated as gherkins. Those of very small size are sometimes called midgets.

The maximum acidity formed by a lactic fermentation of vegetables in brine varies from 0.25 to 2 per cent. The maximum is reached at or soon after the close of the active stage of fermentation. After this the acidity usually decreases slowly. The stage of active fermentation continues for from one to three weeks, depending upon the temperature, strength of brine, etc. During this period gas is formed and froth appears on the surface, owing to the rising of gas bubbles. At the close of this period the brine becomes "still."

The quantity of acid formed depends primarily upon the sugar content of the vegetables fermented, but it may be influenced by other factors.

Dipping a piece of blue litmus paper (obtainable at drug stores) in the brine will show whether the brine is acid. If the paper turns pinkish or red, the brine is acid, but the litmus paper does not give a definite indication of the degree of acidity.

For those who want to know accurately what the degree of acidity is the following method is outlined:

With a pipette transfer exactly 5 cubic centimeters of the brine to a small evaporating dish. To this add 45 cubic centimeters of distilled water and 1 cubic centimeter of a 0.5 per cent solution of phenolphthalein in 50 per cent alcohol. Then run in slowly a one-twentieth normal sodium hydrate solution. This is best done by using a 25 cubic centimeter burette, graduated in tenths. As the sodium hydrate is being added stir constantly, and note carefully when the entire liquid shows a faint pink tint. This indicates that the neutral point has been reached. Read off carefully the exact quantity of sodium hydrate required to neutralize the mixture in the dish. This number multiplied by 0.09 gives the number of grams of acid per 100 cubic centimeters, calculated as lactic, present in the brine.

This method can be used to determine the acid strength of vinegars. Multiply by 0.06 to ascertain the number of grams of acetic acid per 100 cubic centimeters present in the vinegar.

The apparatus and chemicals needed for this test can be obtained from any firm dealing in chemical apparatus and supplies.

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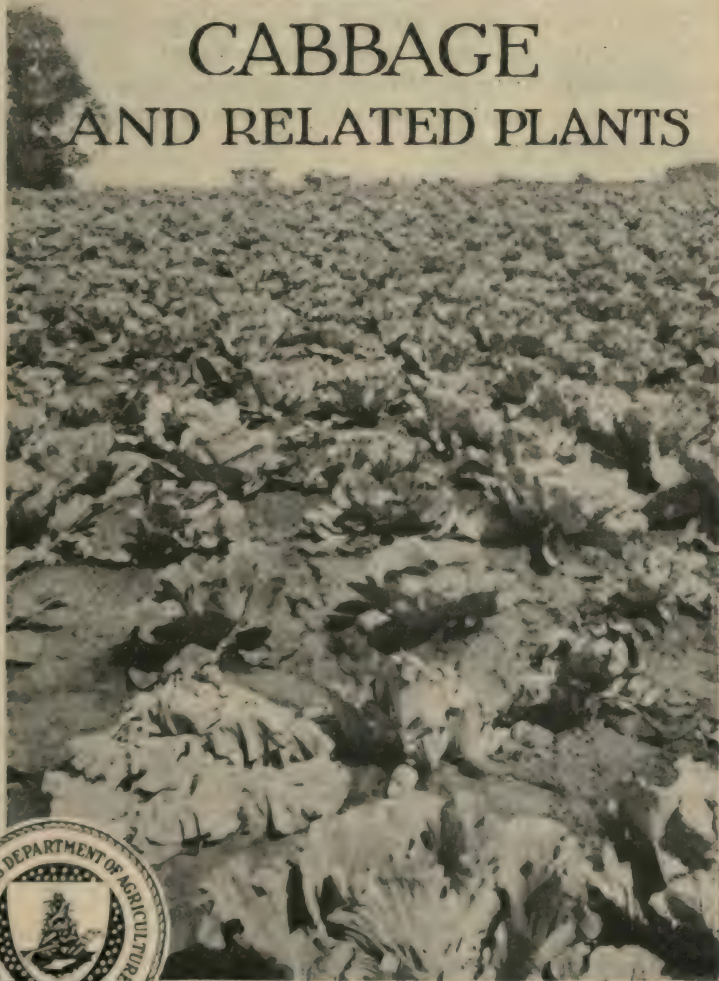
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1439

DISEASES OF
CABBAGE
AND RELATED PLANTS



CABBAGE DISEASES are preventable in the main by simple means of plant sanitation.

Rotation of crops should be practiced, avoiding crops which belong to the cabbage family, such as cauliflower, turnips, Brussels sprouts, and kale. Keep down mustard and related weeds which harbor cabbage pests.

Drainage water and refuse from diseased cabbage fields will carry infection. So will stable manure with which diseased material has been mingled.

The seed bed is often the source of infection. The greatest pains should be taken to insure healthy plants. Locate the seed bed on new ground, if possible, or sterilize by steam the soil used.

Clubroot is avoided by the free use of lime and by setting healthy plants. Disinfect all cabbage seed before planting, to prevent black rot and blackleg. Yellows is due to a fungus which persists in the soil for many years. Varieties of cabbage resistant to this disease are available.

This bulletin is a revision of and supersedes Farmers' Bulletins 925 and 1351.

DISEASES OF CABBAGE AND RELATED PLANTS

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CABBAGE AND OTHER CRUCIFERS

FROM the original wild stocks of the cabbage group have come our cultivated cabbage, cauliflower, broccoli, Brussels sprouts, kohl-rabi, collards, and kale. Other cultivated plants closely related to those already mentioned are turnip, radish, rape, rutabaga, and charlock. Among the related wild plants shepherd's-purse, pepper-grass, and mustard are of most frequent occurrence. Mustard is sometimes cultivated, but it grows so profusely under all conditions that it is perhaps better classed as an obnoxious weed. The term "crucifers" used in this bulletin refers collectively to all the vegetables and weeds mentioned in this paragraph, which belong to the botanical family Cruciferae, so called from the form of the 4-petaled flower. Many of them are subject to the same diseases, so that the methods of control of the diseases of cabbage can often be applied to other crucifers as well.

IDENTIFICATION OF DISEASES

It is the purpose of this bulletin to describe the outstanding symptoms of each disease, to discuss the nature of the causal agency, and to point out such remedial measures as are known. The various diseases can, to a large extent, be identified by the outward appearance of the affected plants. In certain cases, however, points of

similarity often lead to confusion. In order to aid the reader in diagnosis, the following key is given:

Descriptive key to cabbage diseases

	Page
A. Diseases causing enlargements of the root accompanied by stunting or wilting.	
1. Clubroot-----	8
2. Root knot-----	9
B. Diseases causing yellowing of the foliage, not in delimited spots.	
a. With discoloration of the veins and often one-sided development of the leaves.	
a-1. Dark browning of veins.	
3. Yellows-----	11
a-2. Blackening of veins.	
4. Black rot-----	16
b. Light green or yellow cast between the veins; no discoloration of veins.	
5. Malnutrition-----	18
c. Yellowing at margins of leaves followed by dying of tissue; no discoloration of veins.	
6. Tipburn-----	20
C. Diseases causing blackening of roots and lower portion of stem.	
7. Wire stem-----	20
8. Blackleg-----	21
D. Diseases causing dark or gray spots on leaves and stems.	
8. Blackleg-----	21
9. Ring spot-----	24
10. Black leaf spot-----	24
11. Spot disease of cauliflower-----	25
E. Diseases causing mildew or white or yellowish spots on leaves and stems.	
12. Downy mildew-----	26
13. Powdery mildew-----	26
14. White rust-----	27
F. Diseases causing rotting of the heads in the latter part of the season or in storage.	
15. Soft rot-----	27
16. Drop (watery soft rot)-----	28
17. Rhizoctonia head rot-----	29
18. Pythium head rot-----	29
G. Diseased condition caused by climatic agencies.	
19. Flooding-----	29
20. Freezing-----	30
21. Lightning injury-----	30

HOW THE VARIOUS DISEASES ARE DISSEMINATED

Fungous and bacterial diseases are carried from one place to another by various means, such as (1) insects, (2) infected seed, (3) transplanting from an infected seed bed to the field, (4) surface drainage water, (5) cabbage refuse and stable manure, (6) farm animals and tools, and (7) wind.

INSECTS AS DISEASE CARRIERS

Insects frequently are distributors of disease. For instance, the bacteria causing the black rot of cabbage are carried from one plant to another and from one leaf to another by slugs, snails, etc. Insect wounds offer favorable places for infection with certain diseases. Insects which visit cabbage and other crucifers are likely to carry

the germs on their bodies and deposit them on the parts of noninfected plants. If the conditions are favorable, infection then takes place.

Certain insects are attracted to diseased areas of plants by the odors emitted therefrom. Cabbage affected with clubroot has a very offensive odor at some stages in the development of the disease, and this odor has been known to attract insects. The insects, burrowing through the ground or feeding upon the roots, carry the disease from the roots of one plant to those of another.

INFECTED SEED

Cabbage growers seldom raise their own seed, but usually receive it through the customary seed trade channels located in different sections of the United States or even in foreign countries. The germs of several of the most serious cabbage diseases, including black rot and blackleg, are commonly carried with the seed. For this reason it is of fundamental importance that the source of seed be known and that precautions be taken to lessen the danger from seed-borne diseases. As to the source of seed, the evidence indicates that the Puget Sound district is relatively free from blackleg and black rot, and there is ground for hope that owing primarily to climatic factors it may remain so permanently. In any case it is always advisable as a precautionary measure to treat the seed with some disinfectant before sowing (see pp. 5-6), unless it is known with certainty to be free from seed-borne disease germs.

TRANSPLANTING

Plants that are started in a crowded seed bed, which is often located on old cabbage ground near the house or in the garden, are frequent carriers of diseases to a noninfected field. In such crowded conditions diseases are readily communicated from one plant to another. The loss in the field can be greatly reduced if care is used to prevent the introduction of disease into the seed bed, by proper disinfection of the seed and selection of clean soil or by soil disinfection where rotation is impracticable.

SURFACE DRAINAGE WATER

Drainage water or the run-off during heavy rains probably furnishes one of the most important means for the dissemination of plant diseases and has been found in many places to explain the presence of a disease in fields where cabbage or other crucifers have never before been grown. If the crop is planted on high ground the germs from the refuse of diseased plants may be washed to the low-lying fields during heavy rains. In the hope of avoiding disease by crop rotation a new field on this low ground may be selected where the disease will prove as severe as on the abandoned field.

In some sections where cabbage is grown on a commercial scale it is customary to set the plants with a machine which drops about a half pint of water for each plant. For this purpose the water from drainage ditches, which is often the run-off from a field where some bad disease has been present, being the most available, is frequently

used. This use furnishes another method of spreading disease, as was illustrated in a field set to cabbage for the first time, where the water used in setting a part of the field was obtained from a well; for the remainder, water from a drainage ditch adjacent to a field planted to cabbage the previous year was used. The plants set in both portions of the field were obtained from the same seed bed. The yellows was very severe where the plants were set with water from the drainage ditch; the other part of the field was free from it.

CABBAGE REFUSE AND STABLE MANURE

A not uncommon practice is to throw the refuse of cabbage or other crops on the manure heap, the compost thus formed being hauled out and distributed on the fields the following spring. Near sauerkraut factories the refuse is often spread directly on the cabbage land and plowed under. These are bad practices if the crop is diseased, as the causal organisms may thereby be readily disseminated.

The value of cabbage leaves as fertilizer is doubtful. They contain nearly 90 per cent of water, so that even if all the dry matter had fertilizing value, the quantity is ordinarily so small as to be of minor importance. In any case the refuse should be plowed under on fields designed for the culture of crops other than cabbage or its relatives.

The stems and chaff from even mildly infected seed plants may serve as a source of disease. One case has been noted where surface drainage water carried the blackleg fungus from a pile of such refuse of the previous season to a near-by plant bed, resulting in a general infection. Such material should be burned or disposed of in some other proper manner.

DISTRIBUTION BY FARM ANIMALS AND TOOLS

Although the use of sheep or other animals in cabbage fields is recommended for saving the waste, it should be remembered that the worst diseases are perpetuated in the stem and root tissues, which are not eaten. On the other hand, grazing animals passing from the cabbage lands to other fields may scatter the germs of cabbage diseases. Many of these germs pass through the digestive tract unharmed, and in any case they are easily carried with the soil on the feet of animals. Reasonable care, therefore, should be exercised so that infected soil will not be transported to new cabbage fields by cultivators, other tools, or draft horses. While such practices are in some degree unavoidable in farm operations, these dangers should always be understood and all reasonable precautions taken to avoid them, especially with such serious soil-borne diseases as club-root and yellows.

DISSEMINATION BY WIND

Dissemination by wind is perhaps not so important a factor in the distribution of diseases of cruciferous plants as some already mentioned. Nevertheless, in certain districts where the soil is light, where dry weather prevails a part of the year and high winds are common, spores may be carried long distances. The diseases that

are external to the leaves are more likely to be distributed in this way than parasites which are situated in the soil or in the internal portion of the plant.

FARM PRACTICE IN RELATION TO DISEASE CONTROL

Several methods by which diseases may be carried from one plant to another, from one field to another, or, indeed, from one part of the country to another, have already been pointed out. In view of these facts, the first aim of the farmer should be to prevent, if possible, the introduction and distribution of destructive diseases on his farm. In order to accomplish this several precautions should be observed, of which the more important are the disinfection of seed or the production of disease-free seed, the location and care of the seed bed, and crop rotation.

DISINFECTION OF SEED

American cabbage growers, as a rule, prefer to buy seed rather than grow their own, and in general this custom is based on sound economic principles and is likely to continue. Seed growing is an industry in itself, requiring specialized cultural methods and certain favorable climatic conditions. Because of these facts most of the American supply of cabbage seed is grown on Long Island or near Puget Sound or is imported. Persons engaged in the seed-growing industry, as a rule, are not well informed about most cabbage diseases and use no special precautions to insure the production of seed free from the germs of disease. Certain diseases, including black rot and blackleg, develop on seed plants and are disseminated with the seed, and probably nearly all the other disease parasites discussed in this bulletin may do so under some conditions. It is therefore probable that disease germs are very commonly being distributed with the seed. Unfortunately there is no sure means of determining by examination, microscopical or otherwise, whether or not a certain lot of seed is free from infectious germs, except by growing plants from the seed under conditions favorable for disease development. The cabbage grower may guard against much of this danger by the disinfection of his seed before sowing. The process is simple and safe and is applicable to cauliflower, turnip, and other crucifers, as well as to cabbage.

Procure corrosive sublimate (mercuric chloride) in tablet form at any drug store, and, following the directions on the package, make up a 1 to 1,000 solution in water. Place the seed in a sack of a thinly woven material, such as coarse cheesecloth, having it large enough to allow thorough agitation of the seed. Soak for 30 minutes and follow by a thorough rinsing in clean water. Then split the sack and spread out the seed in a thin layer to dry, stirring as needed. Since **corrosive sublimate is a deadly poison**, care must be taken to keep the solution out of reach of children and farm animals.

This treatment is sufficient to kill germs adhering to the exterior of the seeds. It is therefore an almost perfect measure against seed-borne black-rot germs (see p. 16), but in the case of blackleg (see p. 21) the germ invades the seed coat to a certain extent. In this case the seed treatment is not entirely effective, and with frequent

rains a few infected seeds may be sufficient for a considerable spread of the disease throughout the seed bed. This fact makes it the more important that greater attention be paid by seed retailers, growers, and growers' organizations to the condition of the crop from which their supply comes, as to its freedom from seed-borne diseases. The control of these diseases by their elimination at the seed source is the more desirable because of the lack of complete disinfection for blackleg with the use of mercuric-chloride solution. The establishment of more definite cooperation between seed growers, seed dealers, and cabbage growers in regard to the question of disease-free seed would lead to a reduction in losses from black rot and especially blackleg.

PRODUCTION OF DISEASE-FREE SEED

Blackleg and black rot are more or less prevalent in all of the cabbage sections in the Central, Eastern, and Southern States. With both maladies the germs are readily carried over winter on even mildly infected seed heads, and they then attack the seed plants the following season. From a diseased field it is almost impossible to select with certainty seed heads which are free from these diseases. The most effective means of ridding seed stock from the diseases, therefore, is to start with clean or thoroughly disinfected seed. If such seed is infected with blackleg, the germ may be almost completely eradicated by soaking the seed for 30 minutes in water held constantly at 122° F. This treatment will reduce the percentage of germination somewhat and can therefore be recommended only for special cases and not for general use. By combining clean seed with a clean seed bed (see the next paragraph) and a clean field, these troublesome diseases may be avoided and clean seed produced. The cabbage seed-growing section of Puget Sound appears so far to be free from blackleg. A study of climatic conditions as affecting this disease leads to the belief that the dry season there in midsummer serves to prevent its development in that region. If further observations substantiate previous findings, the control of blackleg may be solved by the consideration of this fact in purchasing seeds or arranging for contract growing.¹

LOCATION AND CARE OF THE SEED BED

Cabbage, cauliflower, and some other plants of the same family are generally started in a seed bed before being set in the field. As previously pointed out, some of the worst diseases of these crops may be transferred to noninfected fields by means of the plants from the seed bed. In order to grow strong, vigorous plants as quickly as possible, compost or stable manure is applied liberally to the seed bed. The mistake is often made of placing the bed on an old cabbage field where diseases may have been present, because the soil happens to be fertile or for other reasons. Furthermore, the manure might be, and often is, taken from the heap where diseased plants have been thrown to compost, or it may be from animals that have fed on diseased cabbage. In either case there would be great danger of intro-

¹ For further details as to seed treatment and the production of disease-free seed the reader is referred to the following: WALKER, J. C. SEED TREATMENT AND RAINFALL IN RELATION TO THE CONTROL OF CABBAGE BLACK-LEG. U. S. Dept. Agr. Bul. 1029, 27 p., illus. 1922. This bulletin is obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents.

ducing the diseases into the seed bed. The transfer of such plants to the field would naturally mean the transfer of the diseases affecting them. To avoid this danger the seed bed should always be made on new soils if possible. Where it is necessary to use old soil which may contain germs, it should be disinfected.

W. W. Gilbert, of the Bureau of Plant Industry, recommends the following methods for disinfecting the seed beds by sterilization: (1) By means of draintile laid in the bottom of the beds, through which steam is passed; (2) by means of an inverted pan under which steam is admitted; or (3) by drenching the soil with a formalin solution.

In the tile method of steaming, lines of 2-inch to 3-inch glazed tile are placed lengthwise in the beds to be sterilized, 2 to 2½ feet apart and 15 inches below the surface, and are left there permanently. They provide drainage for the beds, may be used for subirrigation, and are available at any time for sterilizing the soil, the only outlay for labor being the covering of the beds with boards or a tarpaulin and the connecting of the tile with a boiler by means of a piece of steam hose. The soil need not be moved, and thus a large part of the labor involved in sterilization is obviated. It is advisable, however, to spade up the soil, so that the steam may more readily penetrate it.

Another method of steaming, by means of an inverted galvanized-iron or wooden pan 6 feet wide, 10 feet long, and 6 inches deep, under which steam is admitted, has been used in the sterilization of tobacco seed beds and in greenhouse beds and has given very satisfactory results. The use of steam at a pressure of 80 to 100 pounds and treatment for half an hour to an hour after the soil has reached a temperature of 212° F., as indicated by soil thermometers, has given the best results. Detailed directions for soil sterilization by the method here outlined will be found in Farmers' Bulletin 996.²

Formaldehyde sterilization is accomplished by drenching the soil with a 1 to 100 or 1 to 200 solution of standard formaldehyde (40 per cent), at the rate of three-fourths of a gallon per square foot of area, several days before the soil is to be used. Formaldehyde, however, does not rid the soil of nematodes, as steaming does. This method has been used to good advantage in the sterilization of lettuce beds for the prevention of fungous diseases.

DANGER IN USE OF CABBAGE PLANTS FROM ANOTHER LOCALITY

In this connection it is necessary to warn against an inherent danger from the increasing traffic in cabbage-seed plants. Although it is often the case that one may purchase plants brought from a considerable distance with apparent advantage as compared with the use of home-grown seedlings, nevertheless this practice is always fraught with danger. Numerous cases have been observed where the loss from black rot or blackleg on crops grown from such seedlings was much greater than with home-grown stock planted alongside. Disease infection in such seedlings may occur without being evident upon ordinary inspection, and such diseases as clubroot, root knot, and yellows once introduced may thereafter persist indefinitely.

² REINHART, D. G. STEAM STERILIZATION OF SEED BEDS FOR TOBACCO AND OTHER CROPS, U. S. Dept. Agr. Farmers' Bull. 996, 15 p., illus. 1918.

CROP ROTATION

Because of the fact that the germs of certain cabbage diseases overwinter in soil and refuse, repeated cropping of the soil with the same plant favors the multiplication of the disease organisms. The lack of data as to just how long a time is needed to starve out a given organism, as well as regional variation in climate and soil, makes definite recommendation as to length of rotation beside the point. Blackleg and black rot organisms overwinter in the soil in the North to some extent, but a two to three year rotation of the main field seems to be satisfactory. In the case of yellows, the organism once established is so persistent that its reduction by means of rotation is out of the question. Clubroot is also very persistent in the soil, and long rotation with complete subjection of related wild plants which may harbor the organism is necessary. Even with the less persistent organisms, such as those of blackleg and black rot, fairly long rotation of the seed bed is essential. This is the more important because a small quantity of the organism in the seed bed may spread more rapidly and more widely than in the field, thus causing much greater damage than a similar quantity in the main field.

DISEASES OF CABBAGE AND OTHER CRUCIFEROUS PLANTS

CLUBROOT

Clubroot has been known for more than a century in Europe, where it is widespread in its occurrence not only upon cabbage, but upon other cruciferous crops. It is also known in other parts of the globe, such as Australia and New Zealand. It is widespread in the United States. As a rule it is most troublesome in the market gardening sections around large cities, but in recent years it has become of increasing significance in many larger cabbage-growing regions. The disease affects a large number of wild and cultivated crucifers.

CHARACTERISTICS OF CLUBROOT

The outstanding symptom of the disease is the abnormal enlargement of the roots (Fig. 1). These enlargements may occur on the very small roots, the secondary roots, the taproot, or the underground portion of the stem. As a rule they are thickest at the center, tapering toward either end. The normal processes of the roots are of course disturbed by this malformation. Moreover, the enlargements are protected less against secondary soil organisms, so that decay of the root galls commonly occurs before the end of the season.

The effect of this root disturbance is eventually to stunt the plant. This does not always occur promptly, however. A seed bed, for instance, may show no evidence of disease in the above-ground parts of the plants, but when the plants are pulled they are found to have fair-sized root galls. Likewise, infection occurring in the main field may easily escape notice because the stunting of the plants is often very slow and gradual. Mildly affected plants may form fair-sized heads. If the environmental conditions favor rapid development of the disease the stunting may be sudden and pronounced, and wilting of the plants during the middle of bright days may occur. Permanent wilting may accompany advanced decay of the enlarged roots.

CAUSE OF CLUBROOT

The direct cause of clubroot is a minute organism, one of the slime molds,³ the spores of which remain in the soil for long periods of time. With favorable temperature and moisture, some of the spores germinate and each gives rise to a small motile body which penetrates the underground parts of the cabbage plant. Once within the host it enlarges, probably divides, and progresses slowly through the tissue. The presence of the parasite stimulates abnormal growth of the affected parts, resulting in the galls. Later the organism divides into innumerable individual spores which are so constituted as to be able to withstand long periods of unfavorable weather. They are returned to the soil upon the rotting of the cabbage roots.

CONTROL OF CLUBROOT

Liming the soil is the most specific remedial measure for clubroot. Air-slaked lime is more effective than ground limestone. It should be applied shortly before planting and in sufficient quantity to neutralize the soil, if acid in reaction, and to leave an excess of lime.

It has been shown experimentally that infection takes place more readily in a moist than in a moderately dry soil. Moreover, clubroot is found oftener in low, poorly drained spots in the field than in the higher parts. Good soil drainage therefore is important and where necessary should be combined with the liming.

Seedlings are very susceptible to the disease, and the

utmost precaution must be taken to grow the plants on uninfected soil, or disinfection of the seed bed should be practiced. Furthermore, diseased plants where practicable should be destroyed and not thrown on the manure pile or left in the field. Crop rotation should be practiced; and, as it has been found that the disease will live in the soil for several years, the rotation should be a long one. All cruciferous weeds should be destroyed, and no cultivated crucifers should be used in the rotation.



FIG. 1.—Enlarged roots of cabbage caused by the clubroot organism

ROOT KNOT (CAUSED BY NEMATODES)

In trying to distinguish between root knot and clubroot some confusion is likely to result. Although the organisms causing the

³ *Plasmodiophora brassicae* Wor.

two diseases are quite different, the effects produced on the roots bear some points of resemblance. (Compare figs. 1 and 2.) Root knot is generally characterized by smaller swellings than clubroot, and infection as a rule is more uniformly distributed on the lateral feeding roots. If upon breaking open the swellings on the roots pearly white bodies about the size of a pinhead are found, root knot is to be suspected. These white specks within the swelling are the enlarged egg-bearing female nematodes or eelworms, which cause the disease. The interior mass of clubroot is slightly pinkish or brick colored. Root knot affects a great variety of unrelated plants, while clubroot, so far as known, occurs only on crucifers.

Furthermore, root knot is confined largely to the light, sandy soils in the South, although it may occur in the Northern States.

CONTROL OF ROOT KNOT

Crop rotation has been found to be the most practicable means of controlling this disease, the object being to use crops immune or resistant to root knot for the purpose of starving out the eelworms. When this method of controlling disease is employed, a rotation of at least three years, accompanied by clean cultivation to keep down weeds, should be practiced. There are more than 500 different species of plants already known to be suscep-



FIG. 2.—Enlarged roots of cabbage (root knot) caused by nematodes

tible to root knot, among which are many cultivated plants and numerous weeds.

The following lists of the more important immune or highly resistant crops and of the crops and weeds known to be susceptible to root knot and therefore to be avoided on infested fields will be of assistance in planning rotations for the reduction of the trouble.

Crops largely or entirely immune to root knot

Barley.
Bean, soy (Laredo variety only).
Bean, velvet.

Beggartweed, Florida.
Chufas.
Corn.

Cowpea, Brabham.
 Cowpea, Iron.
 Cowpea, Monetta.
 Cowpea, Victor.
 Grass, Bermuda.
 Grass, crab.
 Grasses (nearly all).
 Kafir.

Millets (nearly all).
 Milo.
 Oats, winter.
 Peanut.
 Rye.
 Sorghum.
 Wheat.

Crops susceptible to root knot

Alfalfa.
 Asparagus.
 Bean, Lima.
 Bean, snap.
 Bean, soy (all varieties except Laredo)
 Beet.
 Cabbage.
 Cane, sugar.
 Carrot.
 Celery.
 Clover, bur.
 Clover, sweet.
 Collard.
 Cotton.
 Cowpea (all varieties except Iron.
 Brabham, Monetta, and Victor).
 Cucumber.
 Eggplant.

Fig.
 Lettuce.
 Muskmelon (cantaloupe).
 Okra.
 Pea, garden.
 Peach.
 Potato.
 Potato, sweet.
 Radish.
 Salsify.
 Spinach.
 Squash.
 Strawberry.
 Tobacco.
 Tomato.
 Vetch, common.
 Watermelon.

Weeds attacked by root knot

Balloon vine.
 Clover, Mexican.
 Fennel, sweet.
 Maypop (passion flower).

Papaya (melon papaw).
 Mayweed.
 Purslane.

On fields badly infested with root knot, only immune or highly resistant crops should be grown, especially if this field is to be used in future years for growing cabbage or other crucifer crops.

If the disease occurs in the seed bed or greenhouse, the soil should be sterilized by live steam in accordance with one of the methods referred to on page 7.

YELLOWS

Cabbage yellows occurs seriously from Long Island to Colorado, including the southern parts of New York, Michigan, Wisconsin, and Minnesota, and southward as far as cabbages are grown as a summer crop. It is worse in warm, dry summers, and does little or no damage in the cooler extreme northern sections or along the northern Pacific coast. The winter-grown cabbage of the Southern States usually escapes the disease. In certain intensive cabbage-growing sections in the region first indicated, especially in the latitude of New Jersey and Maryland westward to southern Wisconsin, Iowa, and Kansas, this disease has been rapidly increasing in extent and seriousness. In bad seasons it may destroy 90 per cent of the crop in individual fields and, indeed, is the limiting factor in success with cabbage as a field crop. The disease may also be destructive to kale, collard, and kohl-rabi. Cauliflower, broccoli, and Brussels sprouts are in the main highly resistant.

CHARACTERISTICS OF YELLOWS

Plants infected with the yellows usually show the characteristic symptoms in two to four weeks after transplanting, but the disease may appear in the seed bed. The first sign is the lifeless, yellowish green color of the foliage. Sometimes the yellowing is uniform; more often it is worse on one side, causing a lateral warping or curling of the stem and the leaves. (Fig. 3.) Early symptoms of



FIG. 3.—Cabbage yellows. A seedling plant dwarfed and leaves curled by one-sided infection. A normal plant of this age should be twice as large.

the disease can be seen by cutting across the base of the stem, where the invaded vessels of the woody ring show a darker water-soaked color than healthy ones. This color deepens to a dark brown with the progress of the disease, but not to a deep black as in the case of black rot. (See p. 16.) The overlying tissues gradually die and collapse, resulting in a discolored sunken surface and the curving or warping of the stem already mentioned. The yellowed plants early shed their lower leaves while making a weak attempt to continue growth above. In the worst case death may result within two weeks or so after transplanting, but most of the plants continue a sickly existence for a month or more, and a few live through the summer, heading imperfectly. (Fig. 4.) In these later stages when the interior browning is most pronounced it may be difficult

to distinguish yellows from black rot; therefore the two diseases are often confused.

CAUSE OF YELLOWS

Cabbage yellows is caused by a soil fungus.⁴ This organism once introduced seems capable of persisting indefinitely in favorable soils even though cabbage is not grown. The parasite requires high temperatures, and even on the "sickest" soils it does not attack the cabbage until the soil warms up to about 60° F. or above, which in the Northern States means midsummer. This explains the varia-

⁴ *Fusarium conglutinans* Wollenw.

tions in the seasonal and geographical distribution of the disease—cool, moist summers tending to lessen the loss and hot, dry seasons to aggravate it. Infection takes place through the roots and is especially injurious immediately following transplanting, when the new root system is being developed. The fungus develops rapidly within the stem and leaves, which are killed and discolored as it progresses from the roots upward. From thus crippling or destroying the absorbing and conducting systems of the plant, gradual starvation results.



FIG. 4.—Cabbage yellows, later stages. Where the plants are not attacked too severely or are somewhat resistant they may continue a sickly existence through the season. Such plants are yellowish and the lower leaves keep dying and falling. The attack is often worse on one side, warping or curling the stems

CONTROL OF YELLOWS

The yellows parasite, if once introduced, persists indefinitely in the soil. Sanitary measures and crop rotation are recommended, but these alone do not suffice to control yellows. Seed-bed infection is one of the worst dangers; hence, great care should be taken to plant the seed in clean soil. Steam sterilization of seed-bed soil may be practiced to advantage by market gardeners, but of course for extensive field operations this can not be done. Even if perfectly healthy plants are transplanted into an infested field they may be

attacked badly. The only safety, therefore, lies either in planting the crop on disease-free land or else in using only yellows-resistant varieties, as listed below. In infested districts especial precautions are necessary to check the spread of yellows to new soil. Farm tools, animals, and surface water are common carriers, and a case is recorded where the disease was introduced by using infected drainage water when setting the plants.

YELLOWS-RESISTANT VARIETIES

All of the older varieties of cabbage in general use in this country are too highly susceptible to yellows to be grown successfully on soil that is infected with this disease. Within every variety, however, a few individuals resist the disease. (See figs. 5 and 6.) By continued selection from such individuals, highly resistant



FIG. 5.—Cabbage yellows. Commercial Hollander, a nonresistant variety (on the left), showing only a few sickly plants still alive among the weeds. Wisconsin Hollander, a resistant variety (in the rest of the field), giving practically a full stand, although the soil was uniformly “yellows sick”

strains have been obtained which will produce a normal crop upon badly diseased soil.

Cabbage growers wishing seed of resistant strains will find them listed for sale by a number of seedsmen. If they are unable to procure them through this channel, they should write directly to the agricultural experiment station in the State in which they reside.

A number of yellows-resistant varieties which are now in general use are listed below. Still others are in process of selection and will be introduced as soon as practicable.

Wisconsin Hollander No. 8.—A selection from Hollander or Danish Ballhead. The variety is somewhat coarser and a heavier yielder than the average strain of the original type. It matures a week to 10 days later than some strains of Danish Ballhead. It is used for late shipping and storage purposes.

Wisconsin Hollander No. 9.—A selection from the above. It is slightly earlier and finer than No. 8. Both strains were developed in southeastern Wisconsin by the Wisconsin Agricultural Experiment Station and are now in general use in that and other sections.

Bugner's.—A selection made from a late storage variety by Mr. Bugner, a gardener near Chicago, Ill. It is very similar to Wisconsin Hollander No. 8 and is highly resistant. It is used extensively in the vicinity of Chicago.

Wisconsin All Seasons.—Developed by the Wisconsin station from All Seasons, which it resembles in type, except that it matures a little later. It is a drumhead variety and is used widely for sauerkraut manufacture in yellow-infested areas.

Wisconsin Brunswick.—Selected from Brunswick at the Wisconsin station. It is a drumhead variety, maturing about the same time as Wisconsin All Seasons. It is used for sauerkraut manufacture though not so widely as the latter.

Maryland Flat Dutch.—Selected from Flat Dutch at the Maryland Agricultural Experiment Station and further improved at the Wisconsin station. It is an extremely late-maturing strain and is not very uniform. Probably for these reasons it has not come into general use.



FIG. 6.—A field with "cabbage-sick" soil, most of the plants having been killed by the yellows. A few plants have withstood the disease, and if such are selected for seed and the process repeated for several years a resistant strain may be obtained. (See fig. 5)

Goepper's.—A variety developed by Mr. Goepper, a gardener near Indianapolis, Ind. It is a selection from Louisville Drumhead and is very resistant to yellows. It is used to some extent in the vicinity of Indianapolis.

All Head Select.—A flathead type selected from All Head Early. It is a mid-season variety and matures about 10 days earlier than Wisconsin All Seasons. It has been developed through the cooperation of the Wisconsin station, the United States Department of Agriculture, and the National Kraut Packers' Association. The first distribution of seed of this variety in any large quantity is that of the 1926 seed crop for 1927 planting.

Marion Market.—A midseason roundhead variety selected from Copenhagen Market under the same auspices as All Head Select. It matures in about the same season as the latter and is thus somewhat later than the earliest strains of Copenhagen Market. Seed of this variety is available for 1927 planting.

Globe.—A midseason roundhead variety selected from Glory of Enkhuizen under the same auspices as All Head Select. It matures in about the same season as the latter and Marion Market. A very limited quantity of seed is available for 1927 planting.

Iacope.—A selection from Copenhagen Market, made at the Iowa Agricultural Experiment Station.

Red Hollander.—A late roundhead variety of red cabbage developed by W. J. Hansche at Racine, Wis. It is highly resistant and matures in about the same season as Wisconsin Hollander No. 8.

PRODUCTION OF SEED FROM RESISTANT VARIETIES

Many cabbage growers provide themselves with seed by selecting and saving heads for planting out the following spring. This is a commendable practice and insures reliable stock at a low cost where equipment for successful storage of seed heads is available. Care should be taken to select heads of good type from thoroughly diseased soil where the few susceptible individuals have been eliminated. Cabbage is cross-pollinated by bees, and the seed plants should not be grown within 40 rods of any other variety. When growing cabbage seed, one should aim to keep the stock free from blackleg and black rot. If the seed plants become infected with either of these diseases, the seed should be disinfected before using.

Since the regions where yellows is severe are not best for cabbage-seed growing, the supply of local-grown seed of resistant varieties has not kept pace with the rapidly increasing demands. This has led to the sending of stock seed from yellows sections to one or another of the commercial cabbage seed-producing centers for multiplication. This practice, though commendable, is fraught with some dangers which will inevitably lead to disappointment unless certain precautions are taken. It should be remembered that the yellows-resistant strains are not absolutely immune, and a small percentage of susceptible weaklings always occurs. In the commercial cabbage-seed sections, where yellows is not a factor, these weaklings are not eliminated by the disease. There may be expected then a gradual reversion to the susceptible type where constant propagation is practiced on healthy soil. Experience, however, has led the writer to believe that there is no marked reversion if only one crop is grown on healthy soil, provided one returns each time to stock seed from heads selected on sick soil. For those who individually or collectively wish to follow this practice the following precautions are recommended:

Produce the stock seed from typical heads selected out of plantings of the resistant variety on "yellows-sick" soil.

Test this stock seed on a sick soil alongside a susceptible variety the following season.

If the stock seed is satisfactorily resistant, it may be used for multiplication in a cabbage seed-growing locality, provided it is completely isolated so as to avoid cross-pollination.

Test the increase crop of seed on sick soil before releasing for general use.

BLACK ROT

Black rot is quite as widespread in its occurrence as clubroot, and very few cabbage regions in the United States have escaped it. Since it is very often started from diseased seed, and the parasite does not remain indefinitely in the soil as do the clubroot and yellows organisms, it is more spasmodic in its appearance in the Northern States. It appears to be more generally prevalent in the South, where the organism persists more easily because of the milder climate. A number of wild and cultivated crucifers are susceptible to this disease.

CHARACTERISTICS OF BLACK ROT

The plant may be affected at any stage in its growth. The disease is confined almost entirely to the above ground parts of cabbage. Infection takes place primarily through water pores at the margin of the leaf. The progress of the disease from this point can frequently be traced through the veins of the leaf (fig. 7, c) by the blackening of the bundles. The marginal infection is later followed by a browning and drying up of the infected areas of the leaf. Invasion also commonly occurs through wounds made on the leaf by biting insects. The organism progresses down the leaf to the main stem, where it may advance up or down. As it goes up the stem younger leaves are invaded. The affected bundles in leaf or stem are always easily recognized, upon cross sectioning, by their blackened appearance. If plants are infected while still young, dwarfing or one-sided growth commonly occurs. In extreme cases heading is prevented. Black rot does not cause a soft rot of affected heads, but it opens the way for soft-rot bacteria (see soft rot, p. 27); consequently soft-rot symptoms are common in association with black rot. For this reason it is dangerous to store heads from fields where black rot occurs.

There are some points of resemblance between yellows and black rot which often lead to confusion. This is occasioned by the fact that both cause discoloration of the bundles and both may bring on one-sided development of the leaves or of the whole plant. In the main the bundles affected by black rot are black and in the later stages they are commonly surrounded by cavities due to breakdown of surrounding cells. With yellows the bundles are brown and no cavities occur.

CAUSE OF BLACK ROT

Black rot is caused by one of the bacteria.⁵ These minute organisms are carried about by insects, spattering rain, surface drainage water, and possibly by wind, or with wind-borne particles of dust.



FIG. 7.—Black rot. a, Section through a cabbage stem, showing the conspicuous ring of black bundles caused by the black-rot organism; b, infection through the veins at the margin of a leaf; c, a cabbage leaf, showing the blackening of the veins as a result of the invasion of the black-rot organism

⁵ *Bacterium campestris* (Tammel) EFS.

They are able to swim about in liquid, and when they come in contact with drops of liquid which collect on the margins of leaves or about insect wounds they enter the water pores or wounded tissue. They are able to penetrate the tissue until they reach the conducting vessels, and from then on they multiply in and progress chiefly through this channel. They may be carried over from year to year in old cabbage tissue, possibly in the soil, and on or within the seed.

CONTROL OF BLACK ROT

Since the causal organism may live in the soil or on seed and may be transmitted by insects, the following precautions should be observed to hold the disease in check:

(1) Seed should be disinfected before sowing, in accordance with the method described on page 5.

(2) Care should be exercised in the preparation of the seed bed, and only manure and soil that are known to be free from the organism should be used.

(3) Crop rotation, whether for the prevention of disease or not, is always a good practice. In connection with the black rot it is very important, since the germs are known to survive the winters of even our northern States. To control the disease by this method the rotation should be one in which no cultivated crucifers or cruciferous weeds are allowed to grow in the ground for two or three years.

(4) Insects, slugs, snails, etc., by crawling from infected to non-infected plants, carry black-rot organisms. When possible they should be kept in subjection.

(5) Livestock should not be allowed to roam at will over diseased cabbage patches, as they may carry the organisms to noninfested fields.

MALNUTRITION, A NONPARASITIC DISEASE

Malnutrition is a trouble which affects cabbage, cauliflower, and other crops, especially in the Southern States. It is quite different from any of the diseases previously discussed, all of which are caused by parasites. Malnutrition may be caused in several ways, such as by the excessive use of mineral fertilizers, the lack of humus, or the accumulation of acids in the soil.

CHARACTERISTICS OF MALNUTRITION

The most characteristic symptom of malnutrition is a change from the normal green of the leaves to a light green or yellow between the veins and around the margins. (Fig. 8.) The lower leaves are the first to show symptoms; then the upper and inner ones. All diseased leaves are perceptibly thickened and so brittle as to be easily crushed between the fingers.

The heads from plants slightly affected are small and immature; when plants are badly diseased no heads are formed.

The roots are small and the lateral feeders few in number and frequently dead at the end. Often the epidermis of the stem at the surface of the soil is injured, the injury closely resembling that caused by the corrosive action of some acids and alkalis.

CAUSE OF MALNUTRITION

Malnutrition is often caused by the following conditions:

Constant, clean cultivation for many years has robbed the soil of most of its original fertility. The farmers therefore naturally turned to the use of commercial fertilizers as a substitute. At the outset better crops were obtained than were possible on the best soils without fertilizers. This led the farmers to believe that fertilizers alone were necessary and the more used the greater the yield. When the returns decreased as a result of this practice the quantity applied was gradually increased until it was not uncommon to add as much as 3,000 pounds of mineral fertilizers per acre for a single crop of cabbage. A large part of the fertilizer applied was not used by the plants, but remained in the soil, where in the course of a number of years a considerable quantity accumulated.

Some fertilizers eventually cause what is popularly known as "sour soil." On the other hand, a small quantity of acid in the soil is not generally injurious; but it is not uncommon to find soil in the South so acid as to require 5,000 to 9,000 or more pounds of lime per acre to neutralize it. No agricultural plants will give their best yield under such conditions.

CONTROL OF MALNUTRITION

In controlling malnutrition three points need consideration: (1) The adjustment of the composition of the fertilizer to meet the crop requirements; (2) the rational use of lime; and (3) the maintenance of the organic matter of the soil.

The composition of the fertilizer or the ratio of the different substances composing it should be such as to give an alkaline rather than an acid reaction, for acid soils have been found to increase and alkaline soils to decrease the severity of the malady. As malnutrition is worst on acid soils, air-slaked lime at the rate of 1,000 to 2,000 pounds per acre should be added. Humus can be supplied to such a soil by the use of stable manure or by growing green-manure crops, such as cowpeas, soy beans, vetches, etc., to be turned under when mature. The results from this method of restoring natural fertility to the soil are ordinarily very marked on the first succeeding crop.

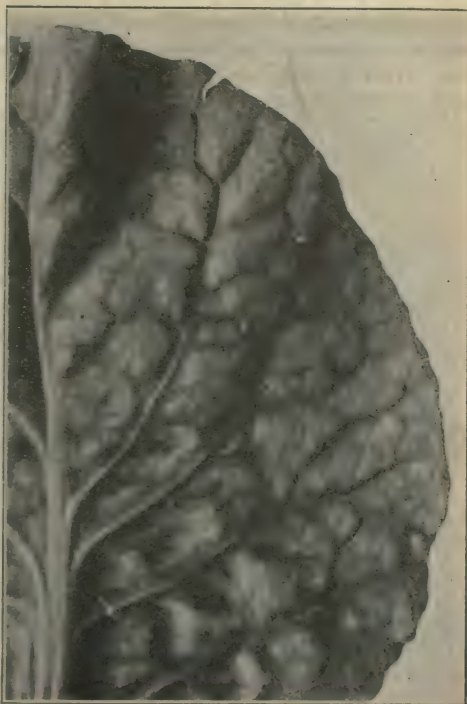


FIG. 8.—A section of a cabbage leaf showing the characteristic symptoms of malnutrition. Between the veins the tissue is a light yellow

TIPBURN

Tipburn of cabbage may be caused by several agencies. Extreme drought sometimes brings on more or less burning at the leaf margins, but this is not of very common occurrence. The most acute cases of tipburn are the result of unbalanced nutrients in the soil. It occurs most commonly in the Northern States in recently reclaimed marsh or muck soils. Ordinarily such soils are deficient in potash and phosphorus and comparatively high in nitrogen.

The disease is characterized by yellowing of the leaves beginning at the margins and progressing downward. Usually the entire margin of the leaf and several leaves of the plant show the symptoms simultaneously. The yellowed tissue dries out and becomes brittle, while secondary organisms commonly attack the dead tissue. This condition usually appears about the time the plant starts to head, and in extreme cases the plants do not form hard heads.

This type of tipburn can be readily prevented by application of potash and phosphate fertilizer. Heavy application of stable manure is also effective.

WIRE STEM OR DAMPING OFF

Wire stem is often encountered as a damping-off disease of seedlings in the seed bed. It is of widespread occurrence in the United States.

The malady may appear when the seedlings are 1 or 2 inches high. The stem becomes water-soaked at the surface of the soil and the plant may topple over and die. Very often the plants show black sunken lesions which may completely girdle the base of the stem and decidedly weaken it. Plants which are growing rapidly and are very succulent are the most susceptible. Plants seem to become more resistant as the stem becomes more woody. Very commonly the seedlings outgrow the disease. Such individuals have in the region of the soil a tough, woody stem which is brownish or black in color.

Wire stem is caused by a fungus⁶ which is widely distributed in many soils. It attacks a large number of plants, including potato, but it is possible that various strains of the organism exist which may be restricted to certain host plants. It appears that the form which commonly attacks potato does not attack cabbage, whereas the cabbage form does not infect potato. The disease seems to progress at any soil moisture or temperature which is favorable for the growth of the plant. It is probable that certain other fungi may cause damping off of cabbage seedlings, but very little study has been made of them and they appear to be less generally prevalent than wire stem.

Sanitation and rotation of the seed bed are essential in the control of wire stem. The disease may be further checked by applying to the soil immediately around the plants a stream of corrosive sublimate solution, 1 to 2,000 (one-half the strength recommended for seed treatment). Apply 4 to 6 days after the plants are up, and repeat at intervals of a week for 4 to 6 weeks.

This treatment is also effective against the cabbage maggot and should be used in any case where that insect is troublesome.

⁶ *Corticium vagum* B. and C.

BLACKLEG

Blackleg occurs very generally in the regions where cabbage has been grown for long periods in most States east of the Rocky Mountains. With the exception of two or three instances of minor importance, it has not been reported from the Pacific coast regions. The loss is ordinarily small if proper precautions are taken as to sanitation, seed bed, and rotation. Where these are disregarded the loss may range from 5 to 10 per cent up to 50 to 100 per cent of the crop. (Fig. 9.)

CHARACTERISTICS OF BLACKLEG

The disease is known to be destructive only to cabbage and cauliflower, but the causal fungus has been shown to be able to attack



FIG. 9.—Blackleg of cabbage, causing the wilting and dying of the lower leaves and a loss of over 75 per cent of the crop in a field

Brussels sprouts, kohlrabi, collards, rape, kale, rutabaga, turnip, radish, sweet alyssum, and variously related cultivated and weed plants of the mustard family. It may invade almost any part of the plant, but the worst damage occurs when it blackens and kills the stems of plants in the seed bed or field; whence its common name.

The earliest symptoms may appear in the seed bed two or three weeks before transplanting time. Infection frequently occurs on the stem near the surface of the ground, causing dark sunken or irregular areas. From these spots the disease spreads, gradually killing the base of the stem and root (fig. 10), so that the plant wilts and perishes. Such wilting of the entire plant is characteristic of the advanced stages of blackleg, and the leaves adhere to the stem (see fig. 9) instead of falling off as in yellows. Frequently plants attacked by blackleg show a purpling of the leaves as the first conspicuous

symptom, even before any wilting occurs. Often the disease may appear as dead spots on the older leaves or leafstalks, and with seed plants the spotting of the flowering branches and seed pods (fig. 10) is common. It is often difficult to distinguish the stem rot caused by blackleg from maggot injury, the more so as the two often occur together. It is also sometimes confused with the wire stem. (See p. 20.) Certain other fungi also cause leaf spots resembling those of blackleg. (See p. 24.) It is important, therefore, to note that



FIG. 10.—Blackleg of cabbage, showing injury and blackening of the main root and diseased spots on the leaf and seed pods, in which numerous small black fruiting bodies of the causal organism are evident

the peculiar character of blackleg which serves to distinguish it is that in its advanced stage the dead areas are covered with minute raised black specks, like pin points. (Fig. 10.) These are the fruiting bodies (pycnidia) of the parasite, filled with the spores by which the disease is disseminated.

Even this symptom may be confused with that of ring spot (see p. 24), which also has pycnidia in the dead areas on the leaf. In the case of ring spot the fruiting bodies are much smaller, more numerous, and more closely crowded together.

CAUSE OF BLACKLEG

Blackleg is caused by a parasitic fungus.⁷ This may be carried with the seed and persists in the soil. The first infections commonly take place in the seed bed, more often in the stems than on the leaves. Maggot or other insect injuries presumably favor infection, although infection occurs readily in the absence of wounds. The rate of development varies widely with temperature and moisture, but under favorable conditions the parasite kills and discolors spots on stems or leaves, and within two weeks these are usually thickly studded with numerous black specks about the size of a pin point. (Fig. 10.)

In these black bodies are contained the spores, which are small and colorless and upon oozing out are distributed primarily by water to healthy leaves and new plants. Wet weather is most favorable to the rapid spread of the disease, while the occurrence of maggots or flooding with water increases its destructiveness.

CONTROL OF BLACKLEG

The blackleg parasite is harbored in the soil by these spore-producing bodies on fragments of the diseased stems and leaves, which may persist two or more years until the old stumps are fully decayed. It is common in seed fields, especially in the Eastern and Central States, and has been reported in Europe. Where it so occurs the seed may carry the infection. The most serious trouble arises from seed-bed infection, either from the use of infected seed or from making the bed on infested soil. The first precaution, therefore, lies in clean seed and seed disinfection (p. 5); the second, in the selection of clean soil for the seed bed. If old soil must be used, it should be steam sterilized where practicable (p. 7).

Inasmuch as the fungus, once established in the seed bed, is spread from plant to plant largely by spattering drops of water, care should be exercised to avoid unnecessary splashing where artificial watering of the seed bed is customary.

The corrosive-sublimate treatment does not completely rid cabbage seed of the blackleg fungus, but greatly reduces it. Where complete eradication of the organism is desired, even at the expense of some reduction in percentage of germinable seeds, hot-water treatment at 122° F. for 30 minutes, without presoaking, is recommended. A preliminary trial with a few hundred seeds should be made in this case, followed by a germination test, since different seed lots vary as to the extent of their injury from this stronger treatment. For further details as to seed treatment and rainfall in relation to the control of blackleg, the reader is referred to Department Bulletin 1029.⁸

Crop rotation should be practiced, and in general sanitary measures are to be recommended. These involve such precautions as can reasonably be taken to destroy or keep from scattering diseased materials. The use of cabbage plants from another locality, the history of which is unknown, is not advisable. (See p. 7.) It is the more dangerous because of the fact that such plants may bear young infections still invisible, which develop rapidly after transplanting.

⁷ *Phoma lingam* (Tode) Desm.

⁸ See footnote 1, (p. 6).

RING SPOT

Ring spot in America is most prevalent on the Pacific coast, where it affects cauliflower, cabbage (including seed plants), kale, and certain other crucifers. It appears in the early stages as dark-purple spots, which gradually enlarge, often becoming an inch or more in diameter on the leaves. (Fig. 11.) The older spots are dark brown, with light-green borders. In advanced stages minute black specks

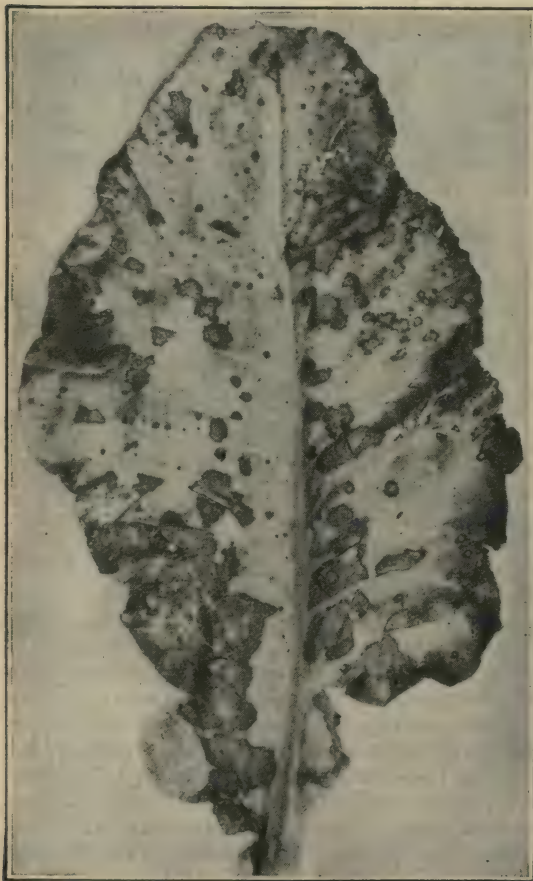


FIG. 11.—A cauliflower leaf attacked by ring spot

appear in the dead portions of the spot, resembling very much those described in the case of blackleg. They are to be distinguished from the latter by being much smaller, more numerous, and thus more closely crowded. The disease appears on the stems and pods of the seed plants as small spots or as long purple streaks. The disease is not often very destructive in this country. Its chief damage is to cauliflower, to which it often causes losses in transit.

Ring spot is due to a fungus² similar in appearance and general character to that causing blackleg. It overwinters on seed or on cabbage refuse.

Successful control measures have not been worked out. It is possible that seed disinfection will prove helpful. Where it is

a transportation or storage-house problem, as is the case with cauliflower, control must be effected through a change in shipping or storage conditions, in which humidity is held as low as possible and the temperature maintained at 32° F. or slightly above.

BLACK LEAF SPOT (BLACK MOLD, BROWN ROT)

Black leaf spot occurs as a leaf-spot of cabbage, cauliflower, collards, and a number of other crucifers. It also causes black mold of

² *Mycosphaerella brassicicola* (Fr.) Lindau.

cabbage heads in storage and a brown rot of cauliflower heads in transit. As a leaf disease it is ordinarily of minor importance, but in storage or transit the organism may be very destructive.

In the field it appears on the lower or outer leaves of the maturing plants as distinct roundish black spots commonly marked with concentric brown zones. (Fig. 12.) These spots vary from one-fourth to one-half an inch or more in diameter. They are distinguished from blackleg spot or ring spot by the absence of the numerous dots (pynidia) in the diseased area. In storage these spots may blend together on cabbage heads until the outer leaves are covered and entirely blackened by the moldy development. On the curd of cauliflower the disease appears as brown spots which turn olivaceous with age.

The disease is caused by a fungus¹⁰ which lives over on cabbage refuse or with the seed. The "black mold" which develops on the leaf spots or upon cabbage or cauliflower heads consists largely of the dark-colored spores of the organism. These are readily disseminated by wind or water and germinate in water, thus invading healthy plants and causing new infections.

Black leaf spot ordinarily is not sufficiently important in the field to warrant the practice of specific remedial measures. Seed treatment is hardly advisable in general, because the mercuric-chloride treatment is not effective, and the hot-water treatment recommended for blackleg is necessary to rid the seed from the organism. The disease being most destructive in storage and in transit, care should be taken to handle the crop so as to minimize the trouble. Heads should be handled carefully to avoid bruising and surface moisture allowed to evaporate before storage. The storage house should be kept at 33 to 34° F. and ample ventilation provided to reduce humidity.



FIG. 12.—Black leaf spot of cabbage; characterized by concentric rings

SPOT DISEASE OF CAULIFLOWER

The spot disease was first found to attack the leaves of cauliflower, but later was observed on cabbage to a more limited extent. It causes on the lower surface of the leaf, and less abundantly on the upper, small brownish to purplish gray spots (fig. 13) somewhat irregular in outline. A puckering of the leaf results when the midrib and larger veins are badly affected.

¹⁰ The common organism associated with the disease is *Alternaria brassicæ* (Berk.) Sacc. Another closely related species may also cause similar symptoms.

During the spring of 1911 some loss was caused to cauliflower in tidewater Virginia, where 25 to 90 per cent of the plants in the worst cases were attacked. It is also commonly prevalent on Long Island.

This disease is due to a bacterium,¹¹ and no means for its control have been worked out. It has been observed that the spot disease is most severe during cool, damp weather, and is held in check when the warm, sunny days of late spring come on. In view of the fact that the organism is especially sensitive to sunshine and warm weather, it is not likely to cause any serious damage except during protracted rainy, cool weather. Crop rotation should be employed in controlling it.



FIG. 13.—Upper surface of a cauliflower leaf, showing typical injury caused by the spot-disease organism

DOWNY MILDEW

Downy mildew¹² first appears in the seed bed in the spring as a whitish mold in isolated spots on the under sides of the leaves. It may also occur on the stems. At the close of the season the portion of the leaf immediately surrounding the diseased area appears yellow and later turns brown and dries up. Frequently light areas are observed in the center of a dark ring, which in turn is surrounded by a light or yellow area, thus presenting a conspicuous mottled appearance. It seldom causes any serious loss except in seed beds. It has been found in Australia and Europe and has been reported from several States in the United States.

The disease is not often troublesome enough to require remedial measures. Crop rotation should be practiced. The plants should not be grown too thick or kept too wet in the seed bed. If in spite of such precautions the mildew is serious, the plants in the seed bed should be sprayed about once a week with Bordeaux mixture (4-4-50 formula).¹³

POWDERY MILDEW

Powdery mildew is caused by a parasitic fungus¹⁴ which forms a white powdery dust on the leaves of turnips, cabbage, and a few

¹¹ *Bacterium maculicolum* McC.

¹² Caused by the fungus *Peronospora parasitica* (Pers.) DeBary.

¹³ This formula is 4 pounds of copper sulphate (blue vitriol) and 4 pounds of stone lime to 50 gallons of water.

other plants. The loss caused by this disease is so slight that treatment is unnecessary.

WHITE RUST

White rust may appear as white blisterlike pustules on any above-ground part of the plant, but more frequently attacks the leaves. Distorted and abnormal growths of the affected parts may follow. It is caused by a fungus¹⁵ which occurs commonly on radish and mustards but rarely on the cabbage in America. Since it is common on European cabbage, it seems probable that the parasite as it occurs on cabbage represents a specialized race which as yet has not been widely introduced into America. If so, efforts should be made through destruction of diseased plants to restrict its spread. Precautions to this end should receive special attention if the disease is detected in the seed bed.

SOFT ROT

The loss from soft rot alone or in combination with other rots is considerable both in storage and in transit. It is occasionally destructive in the field, especially following black rot. Freezing injury is commonly followed by soft rot.

Soft rot of cabbage is characterized by a soft, mushy, almost slimy decay, which after entering, generally at the surface or base of the head, spreads rapidly throughout the whole plant. The soft-rot

bacteria as a class are marked by their ability to destroy plants very quickly under favorable temperature and moisture conditions. They seldom affect uninjured plants, but require a wound or other injury to gain a foothold, or they appear in conjunction with the black rot or black-mold troubles. Infection takes place in the field, where considerable damage may be occasioned, but the greatest destruction to this crop is caused in the cabbage storage houses or in transit. Under improper storage conditions the disease spreads rapidly, frequently covering all of the outer leaves, necessitating repeated and excessive trimming. (Fig. 14.) Soft rot is distinguished from other head rots by a characteristic offensive odor given off from the decayed tissue.

Soft rot in cabbage and related crops is due to bacteria belonging to a group usually referred to as the soft-rot bacteria,¹⁶ which may attack carrots, turnips, celery, and other vegetables.



FIG. 14.—Soft rot developing on stored head of cabbage

¹⁵ *Albugo candida* (Pers.) Roux.

It has been found that in storage houses, where the maximum loss occurs, an increase of the temperature much above the freezing point and a high percentage of relative humidity will result in rapid decay. In view of this fact it is advisable that a temperature uniformly 1 or 2 degrees above freezing should be maintained and a comparatively low relative humidity kept by careful ventilation. Furthermore, cabbage and other crops in preparation for storage or shipment should be carefully selected and so handled that they will be injured as little as possible. Since the soft-rot organisms are especially sensitive to light and drying, the crop where practicable should be dried in the sunshine before being put into storage.

DROP (WATERY SOFT ROT)

Cabbage drop is worst in the Gulf coast region, but is occasionally found in northern States. During some seasons the disease causes heavy losses to the crop in southern Alabama and parts of Florida and Texas. Though its distribution has not been thoroughly studied, it is likely that the disease occurs in other States as well. A serious afterresult is that the crop from such fields, when carload shipments are made, continues to develop the disease in transit. This leads to much loss in terminal markets with the symptom known as watery soft rot.

The earliest symptoms of the disease known as drop are indicated by water-soaked areas over the stem and lower leaves. This wilting of the lower leaves is followed by the whole plant collapsing finally into a shapeless mass. The plant may succumb to the disease in a few days, or it may live from one to two or more weeks. In and about the decayed region a dense white cottony mass of mycelium accumulates. In the later stages of the disease irregularly shaped, hard black bodies, the size of a mustard seed or larger, are to be found scattered among this cottony mass. These bodies are almost sure evidence of the disease.

Drop is caused by a fungus¹⁷ which forms a coarse, white growth in and about the decayed region of the plant which it attacks. Later the hard, black bodies mentioned above develop from the mycelium. These serve to carry the fungus during the period of unfavorable environment. In the spring, they send up small mushroomlike bodies which bear microscopic spores in abundance. These are discharged into the air, and when they come in contact with the moist surface of the host plant they germinate and cause infection.

This fungus is best known as the cause of lettuce drop. It also causes a serious disease of the cucumber, carrot, and certain other plants. In view of this fact, care should be taken in the rotation not to follow lettuce with cabbage on fields where drop has occurred. It is further advisable, when possible, to pull up and destroy infected plants. Compost which may contain the refuse of lettuce, cabbage, and other crops that have been destroyed by the fungus should not be used on cabbage beds or in the field. When cabbage is shipped from areas subject to drop it should be sent under refrigeration in order to hold the disease in check.

¹⁷ *Sclerotinia sclerotiorum* (Lib.) Massoe.

RHIZOCTONIA HEAD ROT¹⁸

The loss from rhizoctonia head rot is occasionally quite serious in the field, though it may also cause damage in storage and in transit. This disease is of widespread occurrence over the central and northern cabbage-growing districts. A short time before harvest, scattered individuals show a dark and firm decay about the bases of the foliage leaves and around the lower portion of the head. The cover leaves of the head soon become dark brown to black and if they are peeled back will show the mycelium of the fungus between the affected leaves. The organism works into the head, producing characteristic dark and sunken spots in the fleshy leaves. Thus many affected heads can not be used for market, but other slightly diseased heads may be brought in from the field and shipped or stored. These decay under average storage conditions and readily spread the disease to adjacent heads. This then produces loss, both from rotted heads in the field and in storage and because of extra labor required for excessive trimming. The rot produced by this organism differs from soft rot in having only a slight odor and attacking healthy uninjured heads in the field. Diseased areas on the plant usually have a few strands of cobwebby mycelium over their surface. The decayed tissue, in the main, has a firmer texture than that of either soft rot or drop.

Rhizoctonia head rot of cabbage is caused by an organism intimately related to the Rhizoctonia which attacks potato¹⁹ but differs in that the cabbage head-rot organism is parasitic only on cabbage. The fungus is most destructive as a head rot in cool weather. It is probably identical with the one which produces wire stem.

Rotation of crops seems to be of little advantage after the disease is established in the soil. Diseased heads should be sorted out and not allowed to come in contact with healthy heads. Cabbage from a diseased field should be handled carefully and if stored kept as near 32° F. and in as dry a condition as possible.

PYTHIUM HEAD ROT

A soft rot of cabbage heads has been described recently, due to still another fungus.²⁰ It has so far been found only in the markets. The disease travels most rapidly along the midrib, which is reduced to a soft, pulpy consistency and held together by the outer layers of tissue. It is not unlike soft rot in appearance, but microscopic examination shows the presence of mycelium in the decayed tissue, while the characteristic offensive odor of soft rot is absent unless bacteria are present as secondary invaders.

INJURIES FROM WEATHER CONDITIONS

FLOODING

Cabbage is frequently grown on rather heavy flat land which is not well drained. Under these circumstances heavy rains may cause surface flooding, especially in low spots. Where this occurs in mid-

¹⁸ This section was prepared by F. L. Wellman.

¹⁹ *Corticium vagum* B. and C.

²⁰ *Pythium debaryanum* Hesse.

summer, so that the ground is covered or saturated with water for a few days, especially if followed by hot, sunny days, the fibrous roots are soon drowned or killed from lack of oxygen. Such roots quickly rot, the leaves wilt, and the plants die. It is important, of course, not to confuse the wilting from this cause with similar wilt due to either of the two parasitic diseases already described, clubroot and blackleg.

FREEZING INJURY

Although cabbage will ordinarily withstand light frosts, heavy freezes as a rule are injurious. Plants vary with their stage of maturity in susceptibility to freezes, and when a field is subjected to such condition before harvest very often the partly mature heads recover, while the mature ones are lost. Sometimes the interior of the head is most susceptible and the damage is not noticed until the head is cut open. Frozen tissue is at first water-soaked in appearance and may later turn dark in color. The affected tissue is very subject to decay by soft-rot bacteria, and soft rot commonly affects frozen stock in storage or transit.

LIGHTNING INJURY

The results of lightning injury are occasionally found in cabbage fields. If noted soon after the injury occurs, the plants are found to be most severely affected near the surface of the soil, followed by wilting of the leaves. Eventually the plants in the affected area die, leaving a roughly circular barren spot varying in size with the severity of the electrical discharge.

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FARMERS' BULLETIN No. 1440

MORE PROFIT *for the* WHEAT FARMERS OF CENTRAL KANSAS



FARMING in the winter-wheat belt of Kansas may be made more profitable (1) by growing more wheat with the same expenditure of labor, equipment, and materials; (2) by growing the same quantity of wheat with less labor, equipment, and materials; or (3) by adding to the work of wheat growing other lines of production that will increase the returns more than the expenses. This bulletin suggests ways in which farmers in this region can do one or more of these things.

Harvesting wheat and putting in the next year's crops are done between the middle of June and the last of October. Limited acreages of corn, oats, alfalfa, Sudan grass, kafir, and the sorghos do not seriously interfere with the production of wheat. A few milk cows, beef cattle, hogs, and chickens provide a means of utilizing farm-grown roughages, wheat pasture, and other feeds produced. These feed crops and livestock give the farmer a profitable return for time not needed in the wheat field.

Twenty-five farmers in McPherson County, Kans., cooperated with the United States Department of Agriculture and the Kansas Agricultural Experiment Station in keeping daily records on their farming business. The farms from which this information was obtained are representative of the usual types of farming in the wheat-growing districts of central Kansas. (Complete analysis of these records is contained in Department Bulletin No. 1296, A Study of Farm Organization in Central Kansas.)

MORE PROFIT FOR THE WHEAT FARMERS OF CENTRAL KANSAS

By JESSE W. TAPP, *Assistant Agricultural Economist, Bureau of Agricultural Economics*, and W. E. GRIMES, *Head, Department of Agricultural Economics, Kansas Agricultural Experiment Station*

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RISKS OF WHEAT FARMING

WHEAT is the most dependable cash crop that can be grown on a large scale in central Kansas. Corn, oats, and alfalfa are other important crops, but they are grown primarily for feed. The hot, dry weather of July and August often seriously damages the corn crop before the grain matures. Kafir, milo, Sudan grass, feterita, and the sorghos stand the dry weather better than corn. Small acreages of these crops are grown on most farms and used as feed for livestock.

Even wheat is not a sure crop in this region every year. In McPherson County, for example, the yield of wheat per acre has been as high as 26 bushels in 1882 and 1883 and as low as 3 bushels in 1895. (See fig. 1.)

Not only are the yields of wheat sometimes low, but often a part of the wheat fails to come through the winter in good condition and is not worth cutting. Some years this amounts to a large part of the crop. The seasons of 1885 to 1887 were very unfavorable for the crops, and the acreage of wheat cut in the county dropped from 158,000 acres in 1884 to 28,000 in 1887. During these years only 44 per cent of the sown acreage of wheat was harvested. This was very discouraging and many farmers left the county. From 1893 to 1895 the price of wheat and the yield per acre were both low and this caused a smaller wheat acreage in 1896 and 1897.

One of the worst years for the farmers of McPherson County was 1910. The fall and winter of 1909 were very hard on the wheat, and the acreage of wheat cut in 1910 was only 6 per cent of the 1909 acreage. Again in 1912 and 1917 a large part of the wheat was abandoned and the land put into spring crops. During the entire period from 1910 to 1922, about 117 acres of wheat was sown in this county for every 100 acres harvested.

These experiences of McPherson County farmers are typical of what happens from time to time over the entire winter-wheat belt of central Kansas. In spite of such discouragement the farmers of central Kansas have continued to depend upon wheat as their most important source of cash income. When the wheat has failed them, they have given more attention to growing corn, oats, and other feed

crops and have kept more cattle and hogs. But with every improvement in the price or yield of wheat, there is a strong tendency to give less attention to other things. However, because of the uncertainty of the wheat crop as shown by the years when a large proportion of the sown acreage was not worth cutting, and by the variations in the yield per acre from year to year, it is not advisable for farmers in this district to depend upon wheat as their only source of income

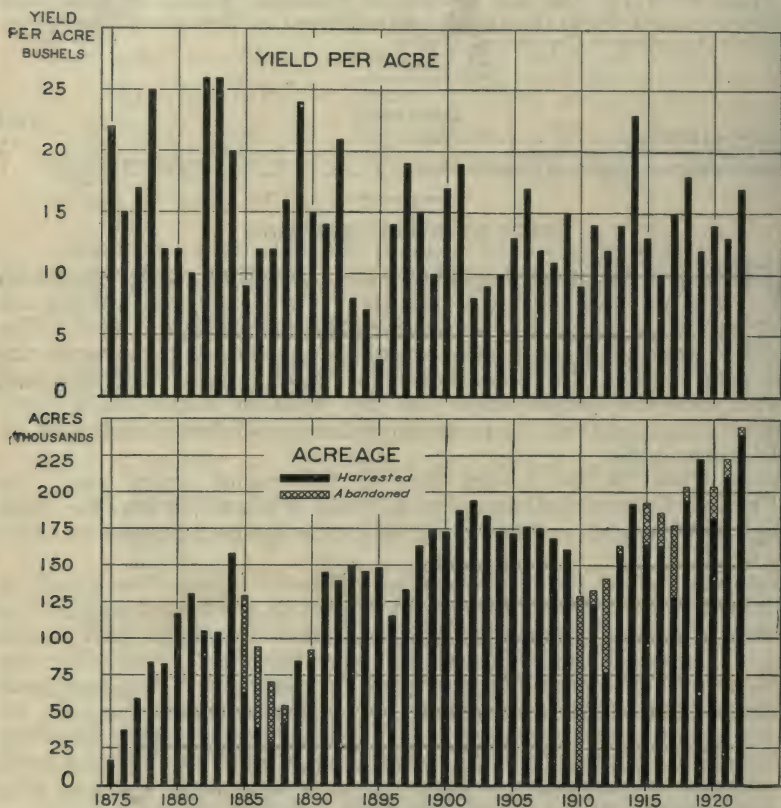


FIG. 1.—Acreage and yield of wheat in McPherson County, Kans., from 1875 to 1922. The amount of wheat harvested per acre in this region is much higher some years than others. Unless the farmer has other things to sell when the wheat crop is poor, he finds it hard to pay the expenses of running the farm

GREATER EFFICIENCY IN WHEAT GROWING

Every wheat farmer in this district should grow all the wheat that he can sow in good condition in the fall without having to hire a great deal of labor for this work or make too large an investment in horses, plows, disks, drills, etc. This will be about 160 acres of wheat on farms where most of the work is done by one regular man, with extra help during harvest and a little other help at different times during the year. This is also about the maximum acreage that can be cut with one binder during the usual period available for binding wheat.



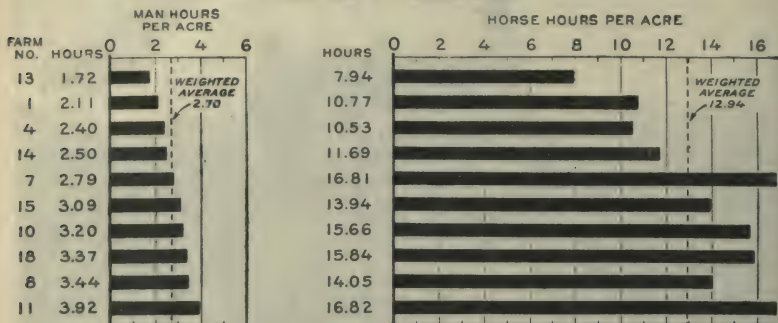
FIG. 2.—Plowing wheat stubble in central Kansas. Wheat usually follows wheat in this area and the land is practically all plowed or listed. Plowing is from 5 to 6 inches deep and is usually followed by one or two harrowings before seeding



FIG. 3.—A 2-row lister in central Kansas. Listing can be done more rapidly than plowing and is sometimes preferred when weather conditions indicate that the soil will dry out rapidly and be hard to work

The acreage of wheat that one man can grow with some help in harvest depends primarily upon the kind of operations and the time used for each operation. Records kept on 25 farms in McPherson County show that with good management the farmer can come up to the following standards in getting the various operations done.

FARMS USING HORSES ONLY



FARMS USING HORSES AND TRACTORS

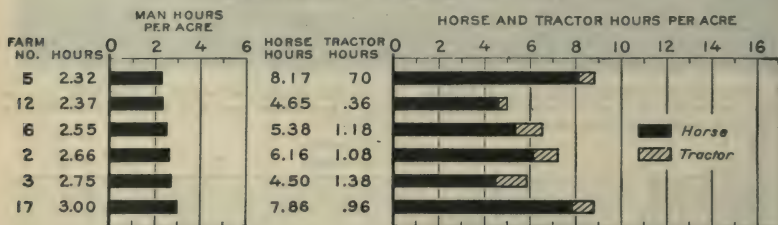


FIG. 4.—Some farmers use twice as much time for putting in their wheat as others use. The size of the implements used, the kind and amount of power used, the condition of the land, the number and kind of operations performed, and the persons doing the work are responsible for these differences

Standard requirements for wheat operations¹

Operation	Size and type of equipment	Acres per 10-hour day
Plowing	2-bottom gang plow and 5 horses	5.6
	2-bottom gang plow and 4 horses	4.4
	16-inch sulky plow and 3 horses	3.3
Disking	8-foot disk and 4 horses (single disking)	20.0
Harrowing	3-section harrow and 5 horses	35.0
Drilling	8-foot drill and 4 horses	20.0
Listing	1-row lister and 4 horses	10.0
	Working down ridges 2-row, 4 horses	20.0
Binding	7-foot binder, 4 horses (14-bushel yield)	13.3
Shocking	(14-bushel yield)	13.3
Stacking bundles	3 men and 2 teams (14-bushel yield)	20.0
Heading	6 men and 10 horses with 10-foot header (14 bushel yield)	30.0

¹In computing these standards, allowance is made for time that must be used in going to and from fields, adjusting machinery, making minor emergency repairs in the field, and similar operations.

In central Kansas there are wide differences between farms in the time of men and horses used in growing wheat. (See fig. 4.) Some farmers come up to these standards in getting their work done; a few do better. Many others can come up to them and grow more wheat with the same labor and equipment or the same amount of wheat

with less labor. By comparing what he does on his own farm with the standards given, the farmer can decide whether he is taking too much time in producing his wheat.



FIG. 5.—A binder in a central Kansas wheat field. Wheat is usually cut with a binder and shocked and some of the bundle grain is usually stacked. The shocked grain is threshed as soon as possible after it is cut



FIG. 6.—A header is used when the wheat straw is short. Farmers with large areas in wheat frequently bind until the wheat is dry enough to head and then head the rest of the crop

To grow wheat with a small number of man hours per acre without omitting any important operations, the farmer must use large-size implements with a large amount of power and have fields of such size and shape that they can be operated efficiently. For example, the hours of man labor needed to plow an acre of land depend pri-

marily upon the size of the plow and the amount of power used. Most of the wheat fields or farms in this area are of such size and shape that large machines can be used to advantage.

But the farmer does not always want to grow his wheat with the smallest number of man hours per acre. To do so he may have to buy new and larger machinery or keep one or two more horses so that he may have larger teams. This might cost him more than he would save in man labor. On many farms the boys or other members of the farm family do a part of the work and do not always get so much done per day as when all the work is done by men. It is usually cheaper to get the work done this way even if it takes a little more time. The time needed for different operations at harvest depends largely upon the yield per acre. Wheat making the higher yield takes more time of men and horses per acre for harvesting, but less

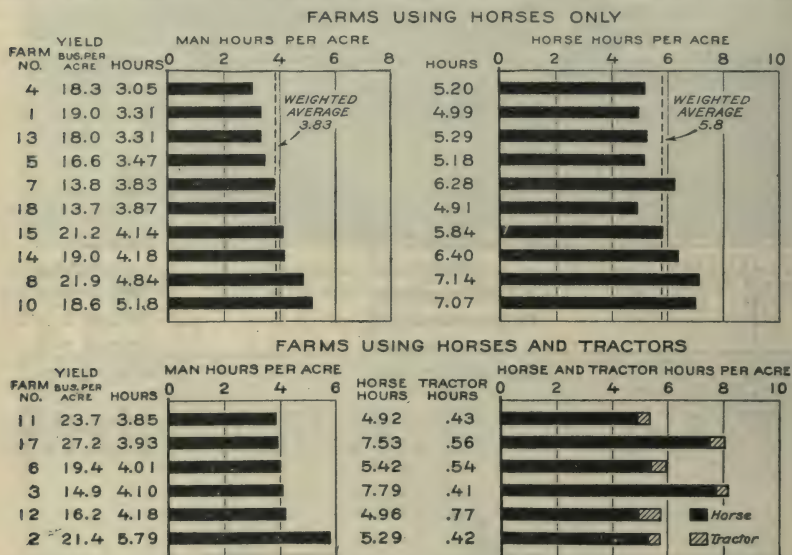


FIG. 7.—Tractors usually do not save man labor in harvesting wheat, as two men are ordinarily used one on the tractor and one on the binder. Two and three horse teams were used for binding on farms, 8 and 10. These hours do not include the time used in hauling the wheat from the thresher

time per bushel. The most efficient wheat grower is the one who secures the most wheat with a given expenditure of labor, horse work, and materials.

Many practices make for greater efficiency in wheat production although they may take more of the farmer's time. Early plowing for wheat increases the chance for a good yield; and, if the land is plowed deep, it also helps to prevent Hessian fly damage. Wherever possible, the land should be plowed in July or the first half of August to get the best results. Deep plowing (about 7 inches), if done early, is much better than shallow plowing. Listing is satisfactory if done early; it is more rapid than plowing, and more ground can be turned early in the season than if it is plowed. Growing wheat in rotation with legumes and the use of manure help to keep up the fertility of the soil and to increase the yield of wheat per acre. (For full in-

formation on these points, see Kansas Agricultural Experiment Station Bulletin No. 219.)

High-yielding varieties of seed that are resistant to winter killing and rust should be used, because they help to increase the yield without greatly increasing the cost. A pure variety usually gives higher yields than a mixture of two or more varieties. Whenever there is danger of damage by Hessian fly, the wheat seeding should be delayed until after the fly-free date. If no flies are present, the seeding should begin earlier to allow the wheat to get a start before winter. (For full information see Bulletin 219 and Technical Bulletin 11 of the Kansas Agricultural Experiment Station.)



FIG. 8.—Corn is often seriously damaged by the hot, dry weather of July and August before any grain matures. The stover or fodder is usually fed to cows, beef cattle, or work stock

ADDING OTHER LINES TO PRODUCTION OF WHEAT FARMING

Wheat is the best income-producing crop in this district and other lines of production must fit in with it. The first step in planning the farm is to grow as much wheat as possible with good methods without having to hire a great deal of labor for seed-bed preparation and seeding work. The next step is to choose the kinds and quantities of other crops and the kinds and numbers of livestock that will make the best use of time and equipment when they are not needed on the wheat. The crops grown and the livestock kept must be so selected that there will be enough feed for the livestock and enough livestock to eat up the feed. In this region the crop yields are uncertain. Consequently several kinds of feed crops should be grown and they should provide enough feed for the livestock in the poorer years. Hay and roughage can be carried over from years of good yields to years when the yields are low and feeds scarce.

²⁰ Kafir, milo, Sudan grass, feterita, and the sorghums stand the dry weather better than corn (fig. 8). Small acreages of one or two of

these crops should be grown, as they insure a supply of rough feeds and the work of growing them does not seriously interfere with the wheat.

The busy time on wheat is from the middle of June to the middle of October. Some stacked grain is threshed and some wheat seeded after October. Hauling grain from the bin to the elevator may be done at any time during the year and does not take up a large part of a farmer's time. Most of the other operations must be done at rather definite times, although the best time for doing such things as seeding and cutting wheat is never exactly the same from year to year on account of the different weather conditions. In planning the work for the year, a farmer needs to keep in mind the usual dates for doing different operations so that he can plan to get all the work done at the right time. Table 1 shows the usual dates between which the different wheat operations are ordinarily done in McPherson County and the number of days favorable for field work.

Usual dates for performing different operations in growing wheat in McPherson County, Kans.

Operation	Dates	Days ordinarily available for field work
Plowing or listing for wheat.....	July 15 to Aug. 31.....	55
Disking or harrowing.....	Sept. 10 to Oct. 5.....	17
Drilling.....	Sept. 25 to Oct. 15.....	14
Binding and shocking or heading.....	June 20 to July 8.....	12
Stacking.....	July 5 to July 20.....	10
Shock threshing.....	July 10 to July 31.....	15

To illustrate the importance of combining other enterprises with wheat growing, the results obtained on a McPherson County farm may be taken as an example. This farm is typical, in the crops and livestock produced, of most of the wheat farms of central Kansas. It is assumed that this farmer wants to find out whether he can make more from farming by continuing with his present system, which consists primarily of wheat growing, or by cutting down on wheat and giving more attention to feed crops and livestock. It is further assumed that when he is making his plans, this farmer decides that for the coming year he can count on the following prices at the farm for the things which he expects to have to sell: Wheat, 90 cents per bushel; butterfat, $37\frac{1}{2}$ cents per pound; pork, 7 cents per pound; beef, $4\frac{1}{2}$ cents per pound; poultry, $17\frac{1}{2}$ cents per pound; eggs, 23 cents per dozen. As to crop yields, he can count on the average yields that he gets, one year with another, on his own farm. Using these yields and prices, the following comparison can be made between the present system of running the farm and a system where more feed crops and livestock and less wheat are produced:

More Profit for Wheat Farmers of Central Kansas

9

Present cropping system

	Acres of crops	Yield per acre	Total
	<i>Acres</i>	<i>Bushels</i>	<i>Bushels</i>
Wheat.....	212	14	2,968
Corn.....	21	20	420
Oats.....	24	25	600
Kafir.....	16	15	240
Total crop area.....	273		
Pasture.....	38		
Farmstead.....	5		
Total farm area.....	316		

All of the corn, oats, and kafir grown and the roughage from these crops were fed to livestock. After keeping out enough wheat for seed, there were 2,700 bushels for sale.

LIVESTOCK

The production and value of the livestock and livestock products were as follows:

Number	Product	Value
4 cows.....	720 pounds butterfat at 37½ cents per pound.....	\$270
4 young cattle.....	1,000 pounds beef at 4½ cents per pound.....	45
3 sows and their pigs.....	5,000 pounds pork at 7 cents per pound.....	350
120 chickens.....	480 pounds poultry at 17½ cents per pound.....	84
	700 dozen eggs at 23 cents per dozen.....	161
Total value of livestock products.....		910

CROP SALES

2,700 bushels of wheat, at 90 cents per bushel.....	\$2,430
Total crop and livestock sales.....	3,340

The cost of materials and threshing for crops

	Twine	Thresh- ing	Seed	Total
Wheat.....	\$48	\$356	(1)	\$404
Corn.....	5		(1)	5
Oats.....	6	48	(1)	54
Kafir.....	4		\$3	7
Total.....	63	404	3	470

¹ Grown on the farm.

COST OF MATERIALS FOR LIVESTOCK

Protein supplement for hogs.....	\$17
Protein supplement for cattle.....	17
Grits and protein supplement for poultry.....	20
Salt.....	4
15 tons of hay.....	150
Total.....	208
Total cost of materials for crops and livestock.....	678
Cost of hired labor (principally for wheat and oats harvest).....	300
Total costs of materials and labor.....	978

After deducting the costs of materials and labor (\$978) from the total crop and livestock sales (\$3,340) this farmer has a net return of \$2,362 left for the use of his land, buildings, equipment, work horses, and for his own time and that of members of his family.

In this region the labor necessary for the rush work at harvest is usually very expensive. On this farm two men had to be hired to help with the cutting, shocking, and stacking from June 20 to the last of July. Help was also needed at threshing time and for some of the fall work on wheat. On 18 farms in McPherson County in 1922, 46 per cent of the labor used for harvesting and threshing wheat was hired. Forty-three per cent of the labor was done by the operator or members of his family and the remaining 11 per cent by exchange labor. On 7 farms where no family help was available, 61 per cent of the harvest labor was done by hired men and 11 per cent by exchanging with neighbors. The work of preparing the seedbed for



FIG. 9.—Alfalfa can be grown very easily in this region. It makes a good pasture for livestock and is the best hay crop of the region. A few hogs can be raised on alfalfa pasture, skim milk, and a little corn.

wheat can be spread out over a longer period of time than the harvesting, and one man without any help can plow, or list, and prepare the seedbed for more acres of wheat than he can harvest. For this reason, hired labor is not used so much for this work as for harvesting.

What changes in crops and livestock will help to increase this farmer's net returns? In answering this question, it must be remembered that the primary need is for crops and livestock that will make the best use of the farmer's time, equipment, and work horses from October 15 to June 15 when there is little to do on the wheat. There is also some idle time between June and October that may be used for other crops without reducing the acreage of wheat that can be grown.

Cattle consume large quantities of straw, corn, and kafir fodder, and other rough feeds, and do well on wheat pasture when it is available. Beef cattle need more attention in winter and take but little of the farmer's time in summer when he is busy with the wheat. Milk cows, on the other hand, need some attention during all the year. However, by having the cows freshen in the fall, they do not



FIG. 10.—A field of Blackhull kafir in Kansas. Kafir, milo, Sudan grass, feterita, and the sorghums stand the dry weather better than corn

take much of the farmer's time during the busy season of wheat harvest and they provide a regular source of income out of which to pay current expenses. The work of feeding and caring for a few hogs may also be done without reducing appreciably the time spent in the field. (See fig. 9.)

PROPOSED CROPPING SYSTEM

More livestock means more feed crops and less wheat unless more land is to be rented or purchased. How the farmer's net returns would be affected by producing more feed crops and livestock and less wheat is shown below:

	Acres	Yield per acre	Total production
		<i>Bushels</i>	
Wheat.....	160	14	2,240, bushels
Oats.....	25	25	625 bushels.
Corn.....	30	20	600 bushels.
Kafir.....	18	25	270 bushels.
Alfalfa hay.....	18	2	36 tons.
Sudan grass.....	5	2	10 tons.
Sudan grass fo. pasture.....	10		
Alfalfa for pasture.....	7		
Native pasture.....	38		
Total.....	311		

All of the crops except wheat are for feed. After keeping out enough for seed and some for chicken feed, 2,000 bushels are left for sale. By using these feeds and the roughages, pasture, and skim milk available, the following livestock products could be produced.

Livestock and livestock products

Number	Product	Value
10 cows.....	2,000 pounds of butterfat at 37½ cents per pound.....	\$750
15 young cattle.....	2,250 pounds of beef at 4½ cents per pound.....	101
5 sows and their pigs.....	8,000 pounds of pork at 7 cents per pound.....	560
200 chickens.....	800 pounds of poultry at 17½ cents per pound.....	140
	1,350 dozen eggs at 23 cents per dozen.....	310
Total value of livestock products.....		1,861
2,000 bushels wheat at 90 cents per bushel.....		1,800
Total crop and livestock sales.....		3,661

The cost of materials and threshing for crops

	Twine	Threshing	Seed	Total
Wheat.....	\$36	\$269	(1)	\$305
Oats.....	0	50	(1)	50
Corn.....	7		(1)	7
Kafir.....	4		\$4	8
Sudan.....			22	22
Total.....	53	319	26	393

¹ Grown on the farm.

Cost of materials for livestock:

Protein supplement for cattle.....	\$120
Protein supplement for hogs.....	20
Protein supplement for poultry.....	15
Veterinary services, medicine, horseshoeing, etc.....	25

Total..... 180

Total cost of materials for crops and livestock..... 578

Cost of hired labor..... 225

Total cost of labor and materials..... 803

After deducting the cost of material and labor (\$803) from the crops and livestock sales (\$3,661) this farmer would have \$2,858 under this plan of operation in return for the use of his land, equipment, work horses and for his own time and that of members of his family. This is \$496 (\$2,858 - \$2,362) more than the returns secured when fewer livestock, more wheat, and smaller acreages of feed crops were produced.

This plan of crop and livestock production would keep the farmer busy in winter and add almost \$500 to his income from farming. It would mean an additional investment of not more than \$500 in livestock. Some of this could be made over a period of years by producing breeding stock rather than borrowing the money to buy them. The interest and taxes on this additional investment would not be more than \$40 or \$50 per year which has not been allowed for

in the expenses. By cutting down the wheat acreage the farm work could be done with 8 horses instead of 10. Provision is made for increasing the production of butterfat per cow from 180 pounds to 200 pounds. This can be done by better feeding practices, particularly the use of more protein supplement in the ration. The cost of the additional protein supplement is included in the cost of materials.

Practically all work on these minor crops and livestock can be done without interfering with the work on wheat. Ample provision has been made for hired labor during busy seasons. It would ordinarily be possible to reduce the cost of hired labor as given by exchanging with neighbors. Although the change in organization means a larger investment in livestock, the cash expenses on these minor enterprises are small and most of the income received from them is net income. As such, it is a direct addition to the total net earnings of the farm business.



FIG. 11.—A few good cows give the farmer a good return for his time in winter and for the corn, alfalfa hay, wheat straw, and other rough feeds which can be grown along with the wheat

How would changes in the prices used in the illustration affect the results? Plans for the farm business must of necessity be based upon the prices which the farmer may expect to get for different products. Conservative prices for the livestock products are used in the example. As long as the production of livestock and the feed crops for them does not interfere seriously with wheat growing, a farmer can afford to include them in the business even if the prices for the products are low. When the price of wheat is low in relation to other things, time can be devoted to these other things more profitably than when the price of wheat is relatively high. Plans for the farm business should be made from season to season on the basis of normal yields, the probable prices for different farm products, and the costs of materials, extra hired labor, seed, twine, etc., necessary for carrying out the different plans. That plan of operation should be chosen which, upon this basis, seems most certain to give the best results.

By renting or buying more land a farmer can grow more feed crops and keep more livestock without reducing the acreage of wheat grown. Many farmers may find it advisable to do this. The exact com-

bination in which crops and livestock should be combined in making up the farm business depends primarily upon the managerial ability of the farmer. By comparing the possible returns that different plans of operating will give for the use of his land, labor, equipment, horses, and other resources, he is in a position to choose the one that will average the most profit. In the example shown, the addition of livestock, and the crops to feed them, gave larger returns. The farmers of central Kansas who have been raising wheat to the exclusion of practically all other products will find that changes in this direction will increase their returns and provide a more regular income.

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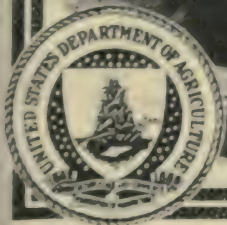
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1441

RURAL PLANNING *The* VILLAGE



CITY PLANNING for convenience, efficiency, health, and social well-being has become a pressing public problem, especially since the rapid increase in urban population. Hundreds of cities have their own town planning boards and numerous others are studying or putting into effect the city plan prepared by experts to overcome intolerable conditions caused by congestion and undirected growth. Attempts to recover from past mistakes or neglect, from carelessness or inertia are costing cities millions of dollars annually.

What of the millions who live in our thousands of villages? What are they doing to make their living and social conditions more healthful, comfortable, attractive, and effective, and to provide for population increase? Villages do not always have the benefit of a detailed town plan prepared by an expert, but rural community effort has already accomplished notable results in many instances.

Why should villages be planned? Who should initiate the planning? Where should responsibility for action and accomplishment lie? How can cooperation effect desirable results? Should plans include the future? What will they cost, how can they be financed, and what difficulties will be encountered?

This bulletin is an attempt to answer these questions by giving instances of what has been done in numerous villages in many States, as well as to indicate the importance of such planning and the facility with which valuable results may be attained. It will not undertake to prepare plans for villages or to discuss technical details, but rather to show by actual accomplishment what may be done by the average country village.

RURAL PLANNING—THE VILLAGE

By WAYNE C. NASON, *Assistant Agricultural Economist, Bureau of Agricultural Economics.*

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WHY VILLAGE PLANNING?

IN THE UNITED STATES nearly 20,000,000 people, or about one-fifth of the population, live in villages. These tens of thousands of villages are also the service stations of more than 30,000,000 farming people, for purposes of business, education, religion, health, and social well-being. Thus the lives of almost half of our population are intimately affected by village conditions. These people, classed as "rural" by the census, produce practically all of our food supply, send leaders into nearly all walks of life, and are the chief conservators of our national ideals.

The approaches, arrangement, sanitation, and attractiveness of these villages, upon which a sound and healthy economic and social country life depends, are of vital importance to the half of our population living in the villages or using them throughout a lifetime. Villages should be easy of access; approaches should be direct, durable, and enjoyable. Physical layouts should be based on naturalness, healthfulness, and convenience; housing conditions should be sanitary, convenient, and economical; dwellings should be satisfactory to the eye and set in pleasant surroundings. There should be clean and well-kept lawns, tree-bordered streets, and good architecture.¹ Dump heaps and congested places should give way to open spaces; and public parks and playgrounds, lake shores, spots of natural beauty, and points of historic interest should be set aside for the use and enjoyment of all. Public buildings should be so located

¹ "It is time that courts recognized the esthetic as a factor in life. Beauty and fitness enhance values in public and private structures People are beginning to realize this more than before and are calling for city planning From the epochal decision of Justice Andrew Holt of the State Supreme Court of Minnesota in the case of the Twin Cities Building and Investment Co. v. City Building Inspector James G. Houghton.

and arranged as to facilitate business efficiency and stimulate civic pride.

All villages can not have all these improvements at once, but they can overcome self satisfaction and plan specifically for the betterment of conditions. The sooner these changes are planned the more easily they will be realized, year by year, even though only one improvement at a time can be made. The plan can be drawn before the village is started, taking into account existing natural conditions and allowing for necessary changes in the future. If the plan is flexible and the goal is always kept in view, the village may easily direct its growth and development, thus avoiding the necessity of making itself over later under great difficulties and at great expense.

The day of isolation has passed. No longer can villages afford to be ugly and unknown. Modern methods of transportation and communication have opened up the hidden places. Millions of tourists travel thousands of miles annually over improved highways. European villages have long realized the economic value of the tourist traffic and have prepared to take advantage of it. They have found that beauty pays, and discovered the inefficiency of the commonplace and the efficacy of individuality and physical distinction in towns as well as in people.

Village planning, whether original or continuous, is not merely a theoretical idea. It is the foresighted application of ordinary business methods in the making of public and private improvements, so that physical development will go hand in hand with social and industrial progress. It is not just a new way of spending money. It is the application of good business principles to the necessary spending of money; the spending of a little to-day that a much greater amount may be saved later. In truth, it is real conservation of public property and genuine economy of public funds.

In the different instances of village planning which follow, some are of definite, initial planning relatively well adhered to in later years; some are a combination of deliberate planning and spontaneous natural development; some are of villages largely replanned at considerable expense and trouble because of undirected early growth; and some are of villages doing one notable thing at a time all directed toward the general future well-being. In all, the human element is uppermost. Group action predominates. Social well-being always results whether it is the direct objective or the consequence of primary economic aims.

TYPES OF PLANNED VILLAGES

VILLAGES REPLANNED

A VILLAGE INITIATES A CIVIC CENTER ON THE 200TH ANNIVERSARY OF ITS INCORPORATION—WESTON, MASS.

A good example of a village with little original planning, which recognized, though tardily, the need of a more attractive and efficient arrangement, may be found at Weston, Mass., a town of 2,282 people, which has recently established a civic center, at the same time doing away with a disfigurement of the landscape. The plan had been agitated for 25 years, but the 200th anniversary celebration of the founding of the town aroused the interest needed to initiate the enter-

prise. The desirability of a civic center was brought to immediate attention through the proposed location by the town authorities of a new fire station house at a place which did not fit in with the improvement plan.

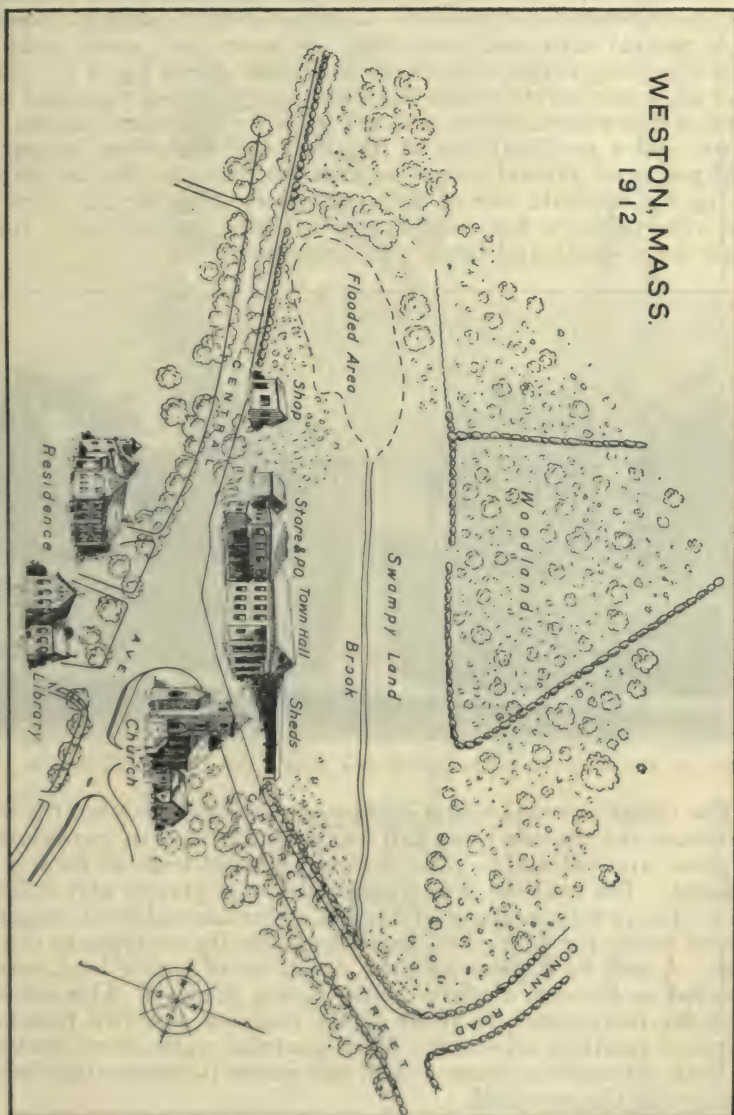


FIG. 1.—The town center of Weston, Mass., before replanning

The objects of the originators of the civic center were: (1) To have important public buildings, including the new fire station, centrally grouped; (2) to prevent an undesired development of an open space in the center of the village about which the erection of small, poorly planned buildings was contemplated; (3) to remove unsightly small

shops and old, unattractive buildings already about this place; (4) to reclaim low, swampy ground, conducive to disease, forming part of this central open space; and (5) to make over this central open space into an attractive town common.

Fronting the central open space at an important street intersection and facing the main street was a group of old buildings, consisting of a general store and post office, the town hall, small tailor and shoe-repairing shops with barns and shed. (See fig. 1.) The old post office was moved across the street to a prominent position in the proposed new civic center and was rebuilt. The town hall was torn down, and a new building of dignified and attractive design, with well-prepared ground improvements, was erected on an elevation facing the opposite side of the open space. (See fig. 2.) One shop was removed to a less conspicuous but still central place, and the other shop, sheds, and barns were destroyed.



FIG. 2.—The new town hall across the new common after replanning, Weston, Mass.

The offensive swamp land occupying the space between the moved buildings and the new town hall was drained, filled in, graded, seeded to grass, and planted to pine, fir, and chestnut trees to form a town common. The oval shape and undulating topography give it distinction. The new fire station, of durable materials and good design, was placed beside the post office, nearly opposite the entrance to the common. A well-built graveled road, one-third of a mile long, was constructed on the side of the common facing the hall. This connected with the main street in front of the common, the two forming an elliptical roadway around it. Wide graveled walks were constructed on both sides of the common and one across it, connecting the main street with the new hall.

To conform to the harmony of the new civic center, the church, located near the post office, was reconstructed and made more attractive in building and grounds. The library was built a few years previous to the contemplated new development but with the anticipation of conforming to it when completed. It was well designed and set in attractive grounds near the church. Recently another

church whose architectural features and setting combine well with the new scheme of things was erected near the post office.

Three streets approach the common by curves, forming a smaller open space with a fountain and flag pole in the center. About this

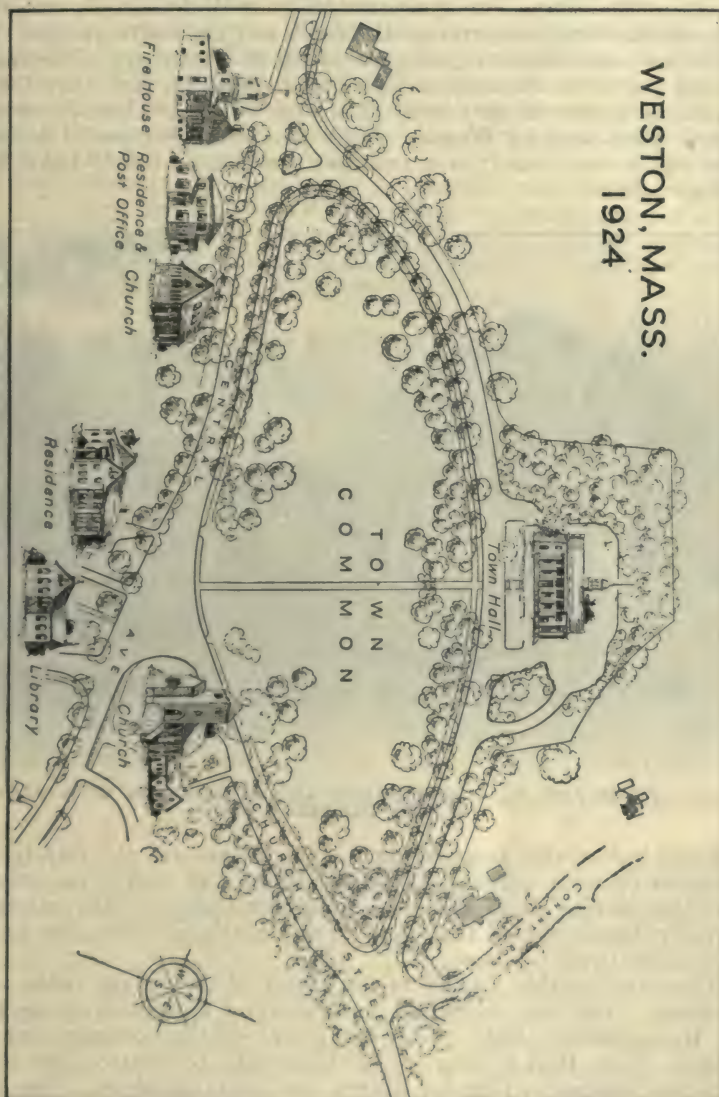


FIG. 3.—The town center of Weston, Mass., after replanning

are placed the two churches, library, new fire station, and post office and general store, while the new town hall occupies a commanding position across the oval common. (See fig. 3.)

These improvements were planned by a landscape architect and were developed in a natural way by the town improvement com-

mittee during the time from 1913 to 1918. The town took the land by right of eminent domain, voted upon at town meeting, and owners were awarded damages. No lawsuits resulted. The project was financed through taxation and from donations.

Of course this work was pursued under difficulties. The blue prints of the plans were prepared 25 years before work was begun. It took that long to overcome the doubts of the cautious ones. Some said that since the town had gone along for 200 years in the old way it was better to let well enough alone. Others said that the plan would be a fine thing for other towns, but that there were exceptional conditions in Weston which precluded successful execution. The result was that it cost twice as much as it would have cost 25 years earlier.



FIG. 4.—North end of common, showing First Parish Church, built in 1747. Cohasset, Mass.

CIVIC BODIES ADD TO CONVENIENCE AND ATTRACTION OF A BEAUTIFUL VILLAGE—COHASSET, MASS.

Long before the Improvement Association and the Sandy Beach Association were formed, Cohasset, Mass. was widely recognized as a village having many desirable planning features. Its citizens had already demonstrated that beauty was not inimical to the practical in modern town progress.

The most notable feature in the center of the village is the ancient common, 1,600 feet in length, with one end approaching the harbor on Massachusetts Bay. Near the center of the common stands the stately First Parish church, built in 1747 to replace the original building erected in 1722 for church and town purposes. (See fig. 4.) South of the church is a natural pond with planned surroundings. (See fig. 5.) Across the street and facing the common stands the town hall and a century-old church; and near the southern end, on a slight rocky eminence, is a church of Gothic architecture. Near this are the post office and the police station, and further on the school, the public library, and another church. With well-kept lawns, century-

old elms, and attractive houses and public buildings this common adds distinction to an interesting village.

Much civic interest has been taken by Cohasset in its harbors. In 1914, at the celebration of the 300th anniversary of the discovery of the place, by Capt. John Smith, the town dedicated a covered public landing well-planted with shrubbery and marked by a commemorating tablet boulder. The town has also provided two landings for fishermen. The village has taken advantage of small open spaces at street intersections to make four of them into triangular parks, each about 200 feet on a side, and a wooded park of 80 acres was presented to the town some years ago.

Notwithstanding the attractive appearance and convenient layout of the village, its people backed by its civic bodies are not content with things as they are and constantly work in various ways to improve it. Three notable efforts along replanning lines have recently been accomplished or are in progress.



FIG. 5.—Natural pond in the center of the common, improved during replanning of Cohasset, Mass.

The restoration of the common was the first. The rocky knoll on which one of the churches stands was formerly a part of the common. During some apparent lapse of civic interest this land had been sold by the town for church purposes. The part of the common between the pond and the church had become occupied by a general store, dwelling, and outbuildings. An awakened civic consciousness, as reflected by the Improvement Association, resulted in the restoration of this second parcel of land to its intended use. After considerable effort and an expenditure of about \$15,000 obtained largely through public subscription from more than a hundred people, the association purchased the land and presented it to the town. The work involved clearing the land of buildings, grading, making important road alterations, and providing improved facilities for automobile parking. This restoration did away with unsightly buildings and brought harmony to the common by making a continuous sweep to the church on the rock. (See fig. 6)

The Improvement Association wanted an inviting gateway to the village. They purchased, with about \$6,500 in subscriptions, the stable lot opposite the railroad station near the end of the common and turned it into a park. They removed unsightly buildings and rubbish, filled in, graded and seeded it, set aside a parking space, and built walls and paths. When landscaping effects have been completed the visitor by rail will have a worthy introduction to better things to be found in the village.

With the gradual but almost total acquirement of the public shore line for private purposes, some citizens feared that no bathing beach would remain for the use of town and country people. To provide for such use, public-spirited citizens formed the Sandy Beach Association and succeeded in acquiring a fine stretch of beach 1,200 feet in length on a partially inclosed body of salt water. At a cost of \$14,000, they removed temporary bath houses and erected a bathing pavilion with 84 compartments, providing 150 lockers, observation



FIG. 6.—Partial view of place where buildings were removed and common restored in replanning of Cohasset, Mass.

platform, lobby, office, fresh-water shower baths, and toilets. Parking space was provided for in front of the pavilion. A good road connects this improvement with the village. Funds were provided by sale of shares of voting but nondividend paying stock. The rental of compartments, lockers, beach chairs, and umbrellas, with fees from users from a distance, serve to make the pavilion self-supporting. It is managed by a board of trustees. Taxes are not assessed upon the property on account of its public nature. Various social features have been put into operation in connection with the pavilion, including popular annual prize swimming races.

All this (fig. 7) has been accomplished without the help of municipal planning boards, but through the zeal of leading citizens and civic associations. Of these results one of the leaders states: "The restoration of the common increased the value of real estate, made the town more attractive and a more desirable place for homes. The station lot improvements added to the creditable appearance of

the town, and the bathing pavilion furnished a community center during the summer where bathing can be enjoyed with comfortable



FIG. 7.—Cohasset, Mass., after replanning. Restored common, center; station park, left; bathing beach and pavilion, upper right

conveniences and under proper supervision. It has proved to be a lesson in community spirit."

VILLAGES ORIGINALLY PLANNED

UNIT PLANNING OF FARM COLONY AND VILLAGE—PATTERSON, CALIF.

Careful initial planning for efficiency of arrangements and as a basis for social development is now the frequent prerequisite of modern farm colonization. Attainment of economic success is coupled with the desirability of a normal social life.



FIG. 8.—General view of planned village. Patterson, Calif.

Patterson village and the colony, the latter a tract of 18,000 acres divided into small irrigated farms, were originally planned in 1910 as a unit, and have been so developed. Comfort and attraction were sought in the roads leading to the village, each being planted with trees or shrubs of one variety.

Led by a chamber of commerce, a farm bureau, two women's civic clubs, and a home demonstration center, and supported by a farming population of 2,000, a village of 694 people has carried on the original plans for an orderly, convenient, and beautiful village.



FIG. 9.—Civic center in the originally planned village of Patterson, Calif.

The dominating feature of the layout of the village is its circular civic center formed by eight streets that approach the center like the spokes of a wheel. (See fig. 8.) At the hub is a well-planned circular plot of ground. There is a building of the prevailing type of California architecture in which are the village post office and the offices of the land company. The eight angles around the plot, formed by the eight streets which meet at the center, are severally occupied by a hotel, two banks, a business block, and two parks, the other two being reserved for future public buildings.

This action of the land company in laying out a village at once convenient and beautiful served to stimulate local civic pride as manifested by the hearty response of the people who, within the past four years, through community cooperation have built a \$12,000 public library, a community club house, a concrete swimming pool (50 by 150 feet), completed and fitted at an expense of \$5,000, a concrete grain elevator erected by a cooperative organization of grain growers at a cost of \$20,000, and a \$70,000 grammar school to supplement existing grammar and high schools. They have developed an automobile camp park and have conducted successful district fairs. In the erection of public and trade buildings, good architecture and planning and careful placing of buildings have been emphasized (fig. 9).

A UNIQUE VILLAGE CENTER—TALLMADGE, OHIO

It too often happened that people from New England and the East left their traditions of beauty and good arrangement behind when founding settlements in the West. Discouraged by pioneer conditions or influenced by the desire for a boom town, good planning often gave way to haphazard methods that produced quicker results.

Tallmadge, in the Western Reserve, was founded in 1807, by Rev. David Bacon, of Woodstock, Conn. Woodstock has always been known as a charming, well-designed village, and it seems probable that it influenced the planning of Tallmadge. As the founder of Tallmadge had been a missionary to the Indians for several years he naturally planned a religious community. The settlers were largely from Connecticut. Purchasing a township approximately 5 miles square, containing 15,225 acres, already laid out into 25 sections of 1 square mile each, he had it resurveyed, dividing it into 16 great lots, each separated by east and west and north and south main roads. Roads were also built from the four corners of the township diagonally to the village in the center, thus subdividing eight of the great lots with diagonal roads from northwest to southeast or from northeast to southwest, the other eight lots also cornering on the diagonal roads leading directly to the village in the center (fig. 10).

In the center of this village a public square of $7\frac{1}{2}$ acres was laid out, and in the center of this square a park was built. It was fenced in, planted to shade trees, and encircled by a public road within the square, a continuation of the converging roads from the country. In 1822 the church was erected within the park, and in 1840 the town hall was built there. (Fig. 11.)

Outside the park and around the square other public buildings, such as library, hotel, another church, stores, and private dwellings, were gradually erected, forming a civic center. The public library was established in 1813 on the joint-stock plan, supported by sales of shares, fines, assessments, and donations.

Compulsory church tithing was an initial requisite of land purchase, but this practice gradually fell into disuse and the community ceased to be of an obligatory denominational type. The general plan of the township and village, however, remains to this day although two corners of the township have since been ceded.

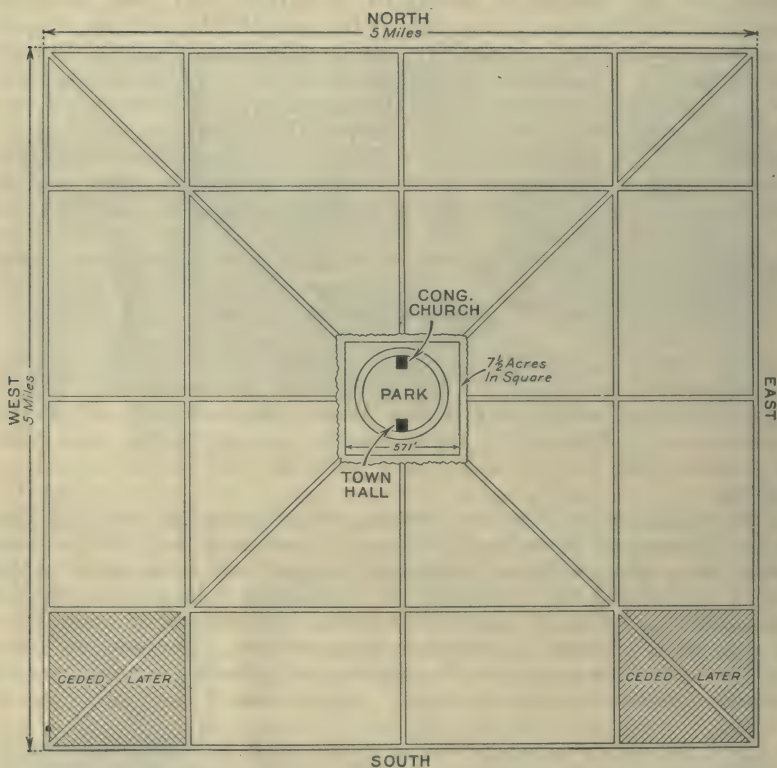


FIG. 10.—Plan of township and village center of Tallmadge, Ohio, as laid out in 1807

The arrangements of the roads produced eight corners at the center and six corners midway between the center and each of the four corners of the township. At each of these four groups of six corners a schoolhouse was established at an early date and other schoolhouses have been added at convenient localities from time to time.

The chief advantages of this plan are the effective grouping of public buildings on or near the parklike square in a civic center, and the short direct lines of communication in contrast with the section-line system of the West. One may go directly from the country to the village or from the country to the country school, and return. This

enables the schools the more readily to become rural community or civic centers.

VILLAGES CONTINUOUSLY PLANNED

AN ATTRACTIVE FARMING VILLAGE WITH NOTABLE CIVIC CENTER— HADLEY, MASS.

It was in 1675 that "the angel of the Lord" appeared and saved Hadley. One of the regicides, a member of the court that had condemned Charles I of England to death, had been in hiding in a secret chamber of the pastor's home. Appearing suddenly to the great surprise of the people at worship, he advised them of an approaching Indian attack and led them to victory, returning to his hiding place again as suddenly and as secretly as he had come, never to be seen by them again.



FIG. 11.—Tallmadge, Ohio, civic center as laid out in 1807. Town hall, right; church, left; both in the circular park of the central square

Even at that time Hadley had some of the elements of a well-planned village. Its now justly celebrated West Street (fig. 12), laid out in 1659, was then the town common, with the village structures, on either side and with the church occupying the center of the common toward the north. The street is 330 feet wide and extends a full mile across the bend of the Connecticut river.

Two roads were laid out, one on each side of this broad street, enclosing a strip of green; and later a double row of elms was planted at the outer side of each road. Between the trees are the walks, and outside are the wide, smooth lawns leading up to the colonial dwellings and outbuildings. At one end of the broad avenue, down the long vista of gigantic, widespreading elms is a memorable view of river and mountains. The common, 40 acres in extent, has had various uses. During Indian troubles, as the village was surrounded by

a stockade it was the public grazing place. It has been used for military drills and for the mustering of large bodies of soldiers, also for public celebrations.



FIG. 12.—Town common, West Street, Hadley, Mass., laid out in 1559, as it appeared in 1923. Road and double row of trees on either side

As the center of population moved eastward another broad street called "Middle Street," was laid out a quarter of a mile east and was later bordered with elms. The principal street crossing these two, also wide and tree lined, is called Russell Street.

Church services were held in private homes until the first church building was completed on the common in 1670. This church was replaced later by a second building, and by a third erected in 1807. Much attention was given to the architectural features of the last building, which was surmounted by a Christopher Wren spire. In 1841, following the trend of population, this church was moved to a spot near the corner of Middle and Russell Streets and was thus the beginning of a noteworthy civic center (fig. 13). About



FIG. 13.—Partial view of civic center, Hadley, Mass. Left to right, primary school, library, town hall, church

the same time the present town hall was erected and located on the principal corner between the church and Russell Street. Of plain though dignified colonial architecture, it occupies a prominent place in the civic group. Directly across the street from the church and town hall, facing Russell Street, is the town grammar school built



FIG. 14.—Continuation of civic center, Hadley, Mass. Left to right, town hall, Congregational Church, intermediate school

in 1894 on a slight rise with broad smooth lawns, the commanding position in the civic center, which a school deserves (fig. 14). Directly across Russell Street from the town hall and opening on two streets is the town library, built in 1902, named after one of the prominent early settlers, and financed by 150 popular subscriptions and a donation. In 1919 it was remodeled as a memorial to Hadley soldiers by adding a gable, by installing rooms for patriotic societies, and by placing a tablet in memory of the soldiers. Close to the library on West Street is located the well-designed primary school.



FIG. 15.—North road gateway to Hadley, Mass.

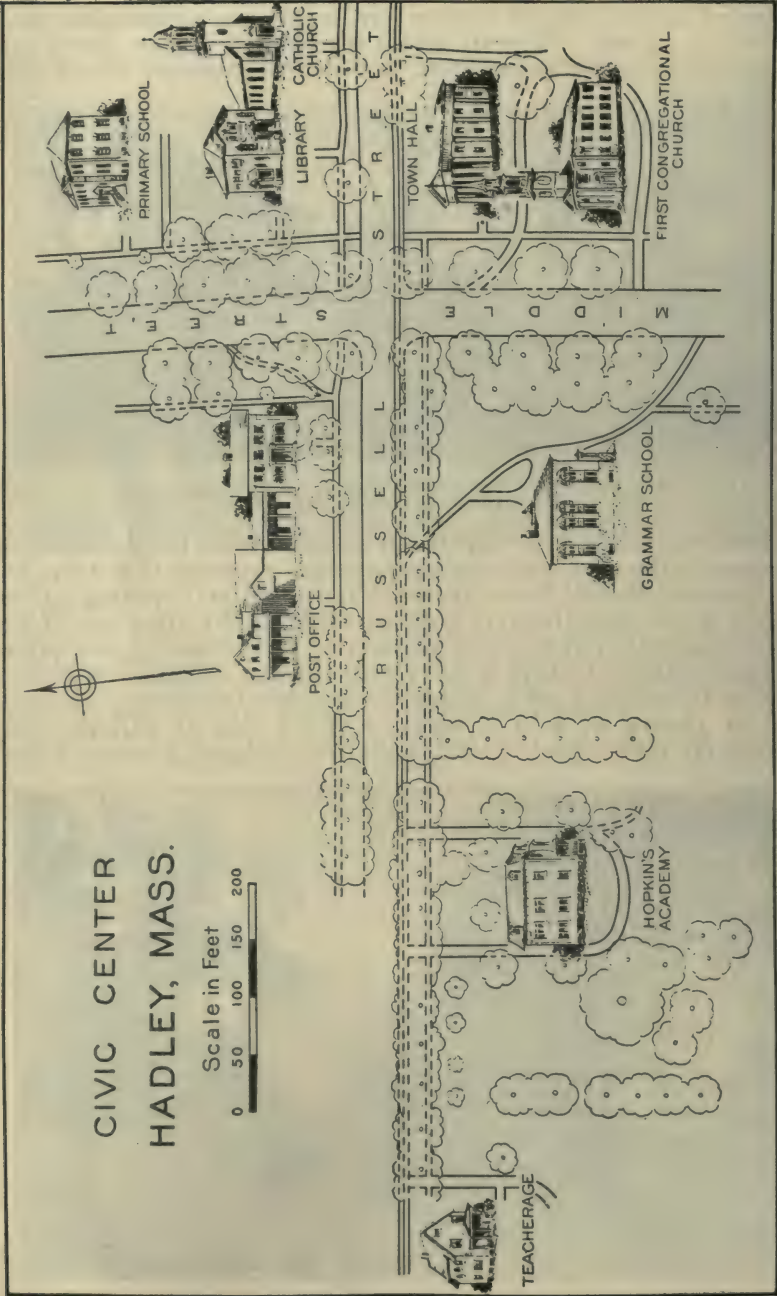


FIG. 16.—Complete view of civic center, Hadley, Mass.

erected in 1922 by taxation. Adjoining the grammar school on Russell Street is Hopkins Academy, said to be the second oldest classical institution of learning in New England, now largely supported by the town for high school students; and just beyond this is the "teacherage." Close to the library on Russell Street is another church; and on the fourth corner, set well back from the street, is the post office and general store.

Thus, in this town of 2,784 inhabitants of whom little more than half live in the center, nine of the town's important public buildings, practically all of them, are grouped about one corner intersected by the two main thoroughfares, on one of which interurban cars pass (fig. 16). Entrance to and departure from the town center are made through attractive gateways. (See figs. 15, 17, and 18.)

The people of the village as well as the people of the outlying



FIG. 17.—South road gateway to Hadley, Mass.

sections are mostly farmers. Those living in the village usually go daily to their fields on the outskirts. All improvements in this town of farmers were proposed, determined, and financed in the general assemblage at the town meeting.

A NEW ENGLAND FARMING VILLAGE—ELLINGTON, CONN.

Of good old English stock, adventurous, religious, independent, which during the eighteenth century gradually pushed its way up the Connecticut River valley from the Saybrook settlements, the people of Ellington were definitely incorporated into a town in 1786. From then until now farming has been the only important industry. The question of how to keep the boys and girls on the farm is never raised. Children take over the farms of their fathers and farms are sold, as a rule, only when there are no children in the family to

carry on. Only thus have the few foreigners gained a foothold here. Of the 2,127 population, the 500 living in the center are mostly retired farmers.

Here is found community spirit at its best. Farmers and villagers, the grange, farmers' clubs, churches, schools, and lodges work together in harmonious relationships. There is much civic pride—pride in well-tilled, clean, successful farms, in beautiful tree-lined roads, in clean streets and parks, in wide green lawns, in stately, dignified public buildings.

The visitor receives many definite impressions. The beautifully shaded approaches seem to welcome him and suggest a village of ordered serenity and contentment (figs. 20 and 21). His first view of the center, with its tall colonial church spire among the trees, is across a fringe of clean, smooth, well-fenced, well-husbanded farms



FIG. 18.—West road gateway to Hadley, Mass.

which encircle the village so closely that there is no room left anywhere for dump piles, ash heaps, and vacant lots filled with weeds and trash (see fig. 19).

The four main roads approaching the village from northeast, northwest, southeast, and southwest merge at an attractive civic center about two small well-kept parks shaded with towering elms and maples. One of these, Church Park, was set aside as church land when the village was founded and was occupied by the church that is now situated in a commanding position across the street.

At Church Park is seen a manifestation of that early civic spirit which has always distinguished the village, for it was about 75 years ago that the pastor, after a stirring lecture on the subject of village beautification, called for volunteers who came the next day in a body to the park and planted elms and maples. Community spirit

is also responsible for the beauty of the adjacent common. On the day in 1910 when the library was dedicated, it was suggested that a "working bee" be held for the purpose of improving the common.



FIG. 19.—Partial view of the fringe about the rural village of Ellington, Conn. Maple Street at right. The fringe on every side of the village is as attractive as this view

During the next two days nearly 100 men, with picks and shovels and with 30 teams, regraded the grounds and planted trees while the women of the village cooked and served lunches.



FIG. 20.—Southeast road gateway from farming community to Ellington, Conn.

Across the street from Church Park is the one church of the center, organized in 1737 (fig. 22), which serves the people of the center and nearly all the people of the town. Situated on a slight rise of ground



FIG. 21.—Maple Street gateway from village to farming community west of Ellington, Conn.

with well-kept lawn and frame of trees and facing the main street and the park, it rightfully takes its place in the town civic center.

West of the two small parks the village library occupies a prominent position among the public buildings and by its dignified architecture adds much to the whole setting. At the other end of the



FIG. 22.—Civic center, Ellington, Conn. Post office through original common at left; town park, front center; well-placed church at right

parks is the post office and general store, the old town hall and the village schoolhouse.

The smooth, wide, tree-bordered main streets make a strong appeal. They are a continuation of the principal roads which, approaching at angles and merging at the civic center, form rather irregular spaces that are more attractive than the regular squares.

Maple Street is bordered for a mile with century-old, overhanging elms and maples planted by the former owners of the abutting farms. At first the street is fringed with rows of cottages set well back from the street, with well-kept lawns. Further on these cottages give way to clean, well-fenced farms with well-tilled fields. In fact, Ellington has many features (fig. 23), simple and inexpensive in nature, which are within the means and possibilities of the ordinary rural community if only the foresight and the will are present.



FIG. 23.—Plan of Ellington, Conn., showing natural road approaches and civic center

A COUNTRY VILLAGE REGENERATES ITSELF—STOCKBRIDGE, MASS.

Up in the Berkshire hills, in the ancient land of the Mohicans, where Rev. Jonathan Edwards and later Rev. David Dudley Field influenced the thought of a nation, there has arisen through the course of years a modern village with many well-planned features which has probably had a greater influence for good on the beauty and cleanliness of other towns than any village in the country. Here was organized in 1853 what is said to be the first village-improvement society in the United States, Laurel Hill Association, which has a record of continuous regular meetings and remarkable achievements for 70 years.

Stockbridge was not always a village with attractive features, although it has always possessed a small common and a wide main street. Previous to the society's organization it was a commonplace village of the hills without sidewalks, parks, or public reservations,

with dusty, ungraded streets shaded by a few trees, with the usual dump heaps, unkempt cemetery and run-down common, with few public buildings or private dwellings of notable architecture. It is now an outstanding example of what a rural village with little original planning may become, if its citizens consciously plan for the future and persistently carry out their plans.

Before any work was attempted, a committee appointed for the purpose spent a winter on the study of the needs to be accomplished. Since then the regular monthly meetings have been devoted to the same purpose. In addition to such committees as finance, sanitation, parks, streets, and cemetery, the village was divided into five districts with a committee to supervise each district. A planting plan was prepared by a nationally-known landscape architect and the committees have attempted to follow this plan.



FIG. 24.—Railroad gateway. Stockbridge, Mass.

The society early stated that its object was to improve, ornament, and care for streets, commons, and walks; to grade and maintain roadways; to plant trees; to lay out watercourses and parks; to beautify vacant places; in short, to work "till art combined with nature shall have rendered our town the most beautiful and attractive in our ancient commonwealth."

A visitor to the place is first impressed with the clean fringe about the village. Next he is surprised to find, in the village center of a town of 1,764 population, a gateway consisting of an attractive railway station and park. (See fig. 24.) When the old wooden station with its usual unkempt surroundings had burned and another wooden one was projected by the railway the association intervened and through its influence a stone building was erected surrounded with lawns, shrubs, and trees. The association provided half the cost, raising the money through popular subscription. It, also, acquired land adjacent to the station grounds, transformed it into a park, and assumed the cost of its maintenance. Entering the

main street, the visitor finds a broad well-paved parked avenue, a mile in length, with green borders, pleasant walks, and overhanging elms, at one end of which is a civic center. The association has planted more than 2,000 trees, has made the entire system of village sidewalks, and is responsible for the draining and grading of the streets.

When the trolley company tried to run a line through the main street, the association and others opposed the proposition and secured public subscriptions for the purchase of another right of way. To do this it was necessary to purchase more land than was needed and 13 acres were fenced, baseball field and tennis courts were built, and the whole was deeded to the town as a recreation park.

The association took its name from Laurel Hill, a 10-acre wooded knoll near the center of town that had been deeded to the association,



FIG. 25.—Part of Stockbridge, Mass., civic center. Front, common; left to right, town hall, chimes tower, Jonathan Edwards monument, church, and rectory

which converted it into a park and playground. The hill has since been the especial care of the association, which holds its annual festival on the hill in a natural amphitheater where a stone rostrum and memorial seat have been built.

The association early took over the care of the cemetery. A hedge of Norway spruce was planted around it, walks and drives constructed, and other shade trees planted. The neglected village green was cleaned, mowed, and planted to trees (fig. 25). Triangular parks were developed at street corners and intersections, where later through private and public effort monuments and fountains were placed, all cared for by the association. It rescued from neglect the burial place of the Stockbridge Indians, making it into a small park marked by a granite shaft. Recently Monument Mountain, a neighboring State reservation, has been placed in its care and many trees have been planted on it. Other results inspired by the association include the planting of individual memorial trees; planting



FIG. 26.—Street corner parks, Stockbridge, Mass., showing fountain and soldiers' monument



FIG. 27.—A well-placed hotel on the main street facing a street corner park and the soldiers' monument, Stockbridge, Mass.

and care of trees by children; private and public yard improvement through stimulation by cash prizes; libraries and reading rooms fostered; the installation by the association of street receptacles for rubbish, and of street lights, running water, sewers, oil street sprinklers, and snow plows.

One value of an improvement society is that it may seek memorial gifts and inspire public donations to the town which add to its interest. The Stockbridge association has encouraged the placing of many such memorials. One of the leading churches is the gift of a local resident. Rev. David Dudley Field presented to the town a neighboring tract of 40 acres containing Ice Glen, a long cleft in a small wooded mountain, filled with caves and perpetual ice formations, which is maintained by the village and the association. This is much visited and has become a well-known picnic place. To this spot every year marches the famous ice-glen parade, usually



FIG. 28.—Memorial bridge on the path to Ice Glen, Stockbridge, Mass.

enacting an historical pageant on Laurel Hill and followed by further festivities at the recreation park and at the town hall.

On the village green, near the site of the early ministerial labors of Rev. Jonathan Edwards, a monument was erected to his memory from money largely subscribed at a reunion of 1,000 of his relatives. Cyrus W. Field presented to the town a small natural park near the village, the site of an old church. On the site of the first Indian mission church, Rev. David Dudley Field caused to be erected, in honor of his grandchildren, a stone campanile containing a clock and a chime of bells. Through the efforts of a member of the association, the Housatonic River near Stockbridge was redeemed. Formerly the village cesspool and dump, its banks were cleared and restored and its waters made clean for boating and other sports. An Italian citizen erected a fountain near the center of the village in one of the small parks, and in another of these parks a soldiers'

monument was placed through public subscriptions and town appropriation. (See figs. 26 and 27.) A memorial to a former president of the association has been built in the form of a walk from Laurel Hill to the Housatonic River and a graceful concrete foot bridge across the river has been erected leading to the path through the glen (fig. 28). One of the most pronounced influences of the association has been upon public and private architecture and landscaping. Prizes offered by the association and public-spirited citizens have encouraged this improvement even in the home-building of the poorer classes, one such prize of \$100 having been awarded to one of the town's most humble citizens.

A new town hall replaced the old building on the green. In addition to the town offices it has a room especially set aside for the use of the grange and contains a large public auditorium. The town library, established largely through popular subscriptions and a donation, is well housed with an attractive setting on the main street. The high school building, also a gift to the town, is very attractive and is fronted by a smooth, well-planted green lawn.

The association does not regard its work as completed and is planning for the future. Its operations are financed by popular subscriptions and gifts and it is now in possession of an invested fund, the income of which is to be used for continued improvement.

TYPES OF PLANNED FEATURES IN VILLAGES

GATEWAYS: RAILWAY

ARRANGEMENT OF RAILWAY STATION GROUNDS OF LIMITED SPACE— PARNASSUS, PA.

The railway station at Parnassus, Pa., is on a narrow strip of ground lying between a main thoroughfare and the railway tracks. Not much ground is available, but an excellent arrangement and treatment of the small space has been effected (fig. 29). The "all



FIG. 29.—An inviting railroad gateway. Parnassus, Pa.

the year round " plan of ground improvements was employed. Trees and shrubs, including hardy perennials, were used. Adjacent lands opposite the street and the tracks have been planted to screen off unsightly places and approaches.

A RAILWAY AND A CIVIC LEAGUE PRODUCE AN EFFECTIVE VILLAGE
ENTRANCE—MOORESVILLE, N. C.

The railway which runs through Mooresville, N. C., has always shown an interest, even in a financial way, in having attractive station grounds. In its general offices a woman is employed whose duty it is to look after and assist such enterprises, and field men to care for the grounds. With such interest on the part of the railway, supported by local pride, there is not much excuse for towns along the line having uninviting gateways.



FIG. 30.—A convenient railroad gateway at Mooresville, N. C.

The railway grounds at Mooresville occupy an important place in the center of the town plan, at the lower part of the V made by the two most important streets converging at an acute angle. On both sides of the street forming this V are the principal commercial buildings. As the lower part of the grounds was much used by merchants as a car unloading place it was very unsightly.

Knowing of the official interest of the railway, the local civic league initiated a campaign for a town gateway which should be in keeping with its prominent position in the town plan. Encouraged by a personal visit from the railway representative, the league proceeded to raise \$50. Another unloading place was secured and, using local equipment and help, the league cleaned up the old place, plowed and fertilized it, and partially enclosed it with a chain fence (fig. 30). The railway furnished shrubs and flowers, did the planting, and pays a gardener to care for these grounds and those of four other stations.

A general town clean-up and improvement movement soon started, extending to private residents, many of whom employed landscape

gardeners to replan their lawns. The league raised more money and greatly improved the run-down cemetery. A prominent citizen states that the new street paving is a direct result of the civic interest aroused by the gateway campaign and its results. The civic league has purchased and reconstructed a building to be used as a community house, at a cost of \$4,500, financing it by receipts from entertainments and the sale of shares. When the vice-president of the railway came to the town he was so impressed with the cooperation of the citizens in improving the station grounds and the town that he promised a new station in keeping with the grounds and the civic pride. Inci-



FIG. 31.—Even a trolley line may have an improved village gateway. Overland Park, Kans.

dentally, the merchant who protested the most urgently, prophesied personal business ruin if the unloading place were removed, and even threatened injunction proceedings, is now an enthusiastic supporter of the enterprise.

GATEWAYS: TROLLEY

PROFITS ATTEND GOOD PLANNING IN RURAL ELECTRIC LINE STATIONS—OVERLAND PARK, KANS.

All electric railways are interested in the material development of the towns and villages through which they pass and many of them have real estate interests in these places, the value of which they like

to increase. An electric line, extending from Kansas City, Mo., into rural Kansas as far as Olathe, has found that good village planning brings much profit. In many of the small villages where it owns real estate it has erected attractive stations in well-planted grounds in an effort so to improve the gateways to the villages that people will not only enter but be glad to remain. For example, in one of these places, Overland Park, a village of 100 people, the electric railway company has built a station plant valued at \$3,000, of which \$1,000 was applied to the preparation of the grounds, 2 acres in extent. The grounds were graded to uniform surface, sown to blue-grass and planted with many shrubs and shade trees (fig. 31). The



FIG. 32.—Trolley station built by citizens. Glen View, Ky.

company believes it is a paying proposition. The general manager says:

Our reasons for beautifying the grounds were that we were large owners of suburban property at Overland Park and other stations and beautifying our stations was an invitation to those who purchase property to do likewise. The result has been the development of a nice suburban district. I believe it is a profitable proposition to develop as we have. Of course we have had similar experience in other localities. Our experience has been that it is much better to start such development right and in the end you will have a better community and a more beautiful residence district.

CITIZENS BUILD TROLLEY STATION AND POST OFFICE—GLEN VIEW, KY.

Some villages are long-suffering in the use of trolley stations that are eyesores. Glen View, Ky., passengers for many years patiently used a dilapidated wooden shack. Finally they decided to build a new station themselves, 10 men becoming financial sponsors.

A stone station with overhanging tile roof was located among the trees on a grassed plot 250 feet long, bordered by hedges, in all costing more than \$2,500. (Fig. 32.) As the Post Office Department was about to close the local office and substitute street boxes, the citizens included in the building a room for the post office. In addition to his small compensation for looking after the mails, the postmaster receives from the community a salary for looking after the station grounds and approaches. The trolley company reciprocates by furnishing electricity without cost to light the building.

GATEWAYS: WATERFRONT

A VILLAGE REDEEMS ITS WATER FRONT—BELLEVUE, IOWA

An example of what a small town may do to clean up its water front and restore it to the dignity that the front door of a town should possess is found at Bellevue, Iowa.



FIG. 33.—An improved water gateway. Bellevue, Iowa

Bellevue, a boat-landing town of 1,700 population on the Mississippi River, had the usual river-front conditions that such towns have to contend with—narrow, poorly lighted streets, vacant lots overgrown with weeds or filled with refuse, and poorly constructed small buildings. About eight years ago it was decided that passengers on passing boats and excursionists from steamers dropping anchor should have a favorable impression of the village. Now in place of the old conditions there is a neat little park of close-cropped greensward with plantings of trees, shrubs, and flowers; a permanent observation and band stand; a large boulder bearing a World War honor roll; a World War cannon, a substantial flagpole, and seats; all approached from the river by a concrete landing, walks and steps 35 feet wide, with attractive electric-light settings. (Fig. 33.) A well-graded, well-lighted street parallels the park. The total cost of

the enterprise was \$8,500, obtained from numerous public subscriptions and a 2-mill town tax.

As soon as the park was completed adjacent property owners began to clean up their premises, paint and repair buildings, and improve their surroundings.

Band concerts, public speaking, and celebrations take place in the park, and when in June 1923, the 250th anniversary of the explorations of Father Marquette and Louis Joliet was celebrated, the people of Bellevue received and entertained their thousands of guests at their new water-front gateway.

GATEWAYS: ROAD

VILLAGE ENTRANCES THAT EXPRESS BOTH WELCOME AND FAREWELL—
SIMSBURY, CONN.

Inviting gateways welcome those who enter and serve as a hearty "come again" to those departing.

Simsbury, Conn., ranks high as a beautiful village with its memorial gateway of stone, bronze, and wrought iron; with its library,



FIG. 34.—North wagon road gateway to Simsbury, Conn.

community house, club building, churches, schools, and private dwellings of harmonious designs and settings; with its wide lawns, its park, and its shaded streets. All of this is anticipated at any one of the three main road entrances, because of the absence of the dilapidated shacks, dump heaps, weed-covered vacant lots and run-down fences so often found along approaches to villages. (Figs. 34 and 35.)

STREETS

IMPROVEMENT OF A MAIN STREET—FOREST CITY, N. C.

Municipal officials can generally be depended upon to vote material improvements, but not so with those aesthetic betterments which

merely make the place more satisfying as a permanent home. Herein lies the value of civic organizations, especially women's clubs.



FIG. 35.—South wagon road gateway to Simsbury, Conn.

In recent years the officials of Forest City, N. C., which has a population of 2,300, have submitted bond-issue propositions to the total value of \$300,000 for waterworks, sewerage, electric light, and school systems which have been approved at the elections. Not satisfied with this, the Ladies' Civic Club finally succeeded in persuading



FIG. 36.—Main Street, Forest City, N. C., as improved by the Ladies' Civic Club

the town officials to permit them to place some parks along the center of Main Street, the club to finance and maintain them.

The street was exceedingly broad, bordered by low buildings with pavement from curb to curb. A landscape architect from a neighboring city was called in to draw plans which provided for three small parks down through the center of the street, a distance of about three blocks, separated by cross streets. The parks are planted with trees, shrubs, and flowers, have cement curbing, are provided with a flagpole, seats, and an inscription stone, and are to be dedicated to the ex-service men of the county (fig. 36). The total cost was \$2,500 secured from the proceeds of entertainments of various kinds and public subscriptions. Maintenance expenses are from \$100 to \$150 a year, obtained from similar sources. The city fathers are now considering taking over the care of the parks.

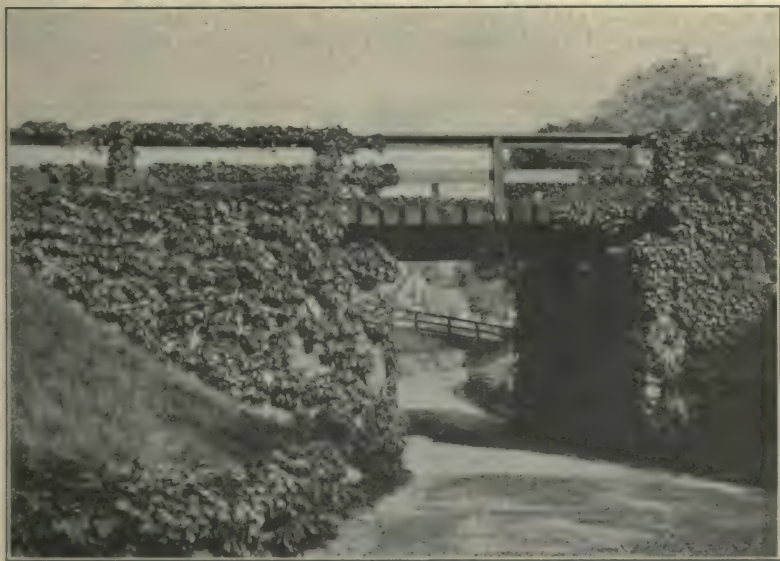


FIG. 37.—Bridges may be beautiful as well as durable, Falmouth, Mass.

BRIDGES

AN ATTRACTIVE BRIDGE AT A VILLAGE PORTAL—FALMOUTH, MASS.

One of the principal requisites for a bridge is durability, but a bridge may be beautiful as well, yet reasonable in cost. With the passing of the old arched stone bridges, concrete has come into use, which for strength and beauty readily takes its place. Shrubs and vines add much to such bridges. Figure 37 shows a bridge about 100 yards from the railway station at Falmouth, Mass., built over a road leading from the village. The concrete abutments and the approaches have been softened and redeemed by a vine, an effective and inexpensive method of treatment.

COMMONS

A NOTABLY ATTRACTIVE VILLAGE FEATURES A TOWN COMMON—
BARRE, MASS.

The town common, the central, green, open but shaded space around which the principal buildings of the town are grouped, is the most attractive and distinctive feature of the New England village. It has become, in many instances, the center of the social life of the people and a place of recreation.

The Barre common, 150 years old, is about 550 yards long by 100 yards wide, tapering at one end, and is surrounded by broad paved streets. Cross streets divide the common into three parts. One end is fenced and provided with a fountain, a war monument, benches, hedges, and gravel walks. A band stand is in the unfenced portion. Large century-old maple trees give abundant shade. (Fig. 38.)



FIG. 38.—A portion of the common at Barre, Mass., is reserved for public celebrations

Facing the common on all sides are the stores and the following public buildings: Town hall built 85 years ago, post office, two hotels, the library building owned by the library association, and four churches. These buildings are well designed, have attractive landscape settings and are well placed on the common. Not far from the common are two school buildings of superior type and a beautiful and well-cared-for cemetery. Plans have been completed for the purchase of certain property abutting a street on the common and its conversion into a park. The common is in frequent use for community fairs, band concerts, memorial exercises and public entertainments.

Since the formation of the village-improvement society, about 30 years ago, the common, streets, and private and public places have been well kept. The town has 3,300 population, the village about 1,500, and the improvement society has 500 members. It maintains the common and parks, builds and cares for sidewalks, plants shrub-

bery and flowers, and for this work regularly employs one or two men. It finances its work by receipts from entertainments, raising about \$3,000 in 1923. It has a yearly budget of about \$1,000 and a balance of \$10,000. A live village-improvement society and a well-planned village usually go hand in hand.

PARKS

THE ORIGINAL VILLAGE CROSSROADS BECOMES THE SITE OF THE VILLAGE PARK—LE ROY, OHIO

Among the local improvements brought about by the village of Le Roy, through the encouragement of the local farmers' mutual insurance company and its employees, was the laying out of an attractive park opposite the two churches near the center of the village. (Fig. 39.) One of these churches, of the colonial type of architecture, had been standing over 75 years and is much prized for its dignity.



FIG. 39.—A country village park with a background of churches. Le Roy, Ohio

The park was one of the results of a far-reaching campaign for village improvement and was laid out by a landscape gardener. It is situated at the old intersection of the two crossroads where the village had its beginning 80 years ago. It is oval in shape and is planted with shade trees and flowers. Well-designated electric lights surround it.

RIVER-BANK IMPROVEMENTS

THE TOWN DUMP BECOMES A SCENIC ASSET—LEWISBURG, PA.

"That place has been there as long as I can remember," said one town father. "There has got to be some place for the town refuse," said another, "and, besides, that's the natural escape for the sewer."

Age and even tradition were on the side of the town fathers. "That place" had been there farther back than memory ran. Every time the people went into the country or across the river to the adjacent city the town dump was the last reminder of home. Every time the people from the country, the neighbors across the river, or the strangers from the big cities arrived in the town their first impression was conveyed by "that place."

But the women citizens were not dismayed. They formed a civic club, began a backfire of agitation and propaganda, and accumulated funds against the time when inertia could be overcome. Through such enterprises as lecture courses, local plays and food sales, and through donations, sufficient money was secured to swing the enterprise. The block of land on the river front between the two bridges finally became the property of the club. Old shacks were removed, refuse cleared away, the ground leveled, lawn made, trees, flowers and shrubs planted, walks built, and electric lights installed. And when the municipal officers couldn't see their way clear to install the pipes to conduct the overflow of the village sewer underground to the river the women held more sales and entertainments and paid for the work themselves. In all more than \$7,000 was raised and spent on the work of redeeming the town dump and improving the river bank.



FIG. 40.—The town dumping ground as redeemed by the Ladies' Civic Club, Lewisburg, Pa.

Now the last impression of the departing visitor is of wide lawns and green trees, and the incoming guest or stranger has the same aesthetic pleasure as a welcome. (See fig. 40.)

LOCAL RESERVATIONS

A PICTURESQUE SPOT PRESERVED FOR PUBLIC SOCIAL USE—BARRE, MASS.

Within the town and adjacent to the village center of Barre, a picturesque stream of water rushes through a deep gorge, forming a canyon to the depth of 50 feet in places. The land on both sides is covered with pine, hemlock, and chestnut trees and a profusion of flowers and ferns. The spot has been a favorite picnic ground for generations and the show place of the town (fig. 41).

Although the abutting land was in private hands, long-continued use had given the community the sense of possession, until the an-

nouncement was suddenly made that the owner was about to cut down the timber, which would practically destroy the value of the spot as a recreation ground.

In an emergency of this kind municipal or community action is preferable; but as both are necessarily slow, the town was fortunate in possessing public-spirited citizen who purchased 20 acres of land covering both sides of the gorge. The village then proceeded to link the glen with its other attractive physical features by attractive road approaches. The purchaser planted 2 acres of pines, built two dams, a bridge, and summer house, made entrances and paths, placed benches and stairways, and erected signs which read, "For the use of the public." Finally, he placed a clause in his will to the effect that after his death the project should become the property of the town.

CEMETERIES

AN ATTRACTIVE CEMETERY LOCALLY PLANNED—LAN- ARK, ILL.

In this village of 1,300 people, a citizen who could draw elementary plans, a zealous caretaker, and a far-seeing board of managers have produced a village cemetery which not only attracts wide attention but has stimulated the better planning of the cemeteries of half a dozen other villages.

For many years after its inception in 1862 this cemetery was little more than a burial place, increased in size as need arose, the property of the village but the especial care of no one. A number of years ago, however, local plans were drawn with a view to the future, plantings were started, and it was later placed in the care of a board of managers appointed by the mayor.

It has an area of 22 acres planted with trimmed arborvitae hedges and framed with elms and maples (fig. 42). Within the area are three small circular parks planted with pine or maple trees, fenced, and provided with benches. Of late years the maintenance expense of \$1,500 yearly, including the salary of a caretaker, and improve-



FIG. 41.—A view in the glen reserved for public social use at Barre, Mass.

ments, has been financed from interest received from an endowment fund obtained from the sale of lots at \$50 each.

PUBLIC BUILDINGS

A GROUP OF BUILDINGS AND A PARK WHICH PRESERVE BALANCE— BRANDON, VT.

No matter how architecturally beautifully and well proportioned a bare group of buildings may be it never attains its full measure of



FIG. 42.—A neglected cemetery redeemed. Lanark, Ill.

beauty until relieved and set off by a growth of trees. On the other hand, a park or common framed by rows of unattractive buildings never attains its best results.

Many years ago the site of the park at Brandon, Vt., was a sandy, treeless place around an old well and surrounded by dilapidated



FIG. 43.—Buildings grouped on a park at Brandon, Vt.

buildings. A number of citizens planted trees there as a town improvement, and later a fountain and a band stand were added. Gradually the bordering groups of ugly buildings were replaced by modern buildings of good design, or new facades were added or old fronts were made uniform, resulting in a greatly improved appearance.

As the park is the center from which important streets radiate, and as it is now lined on all sides by groups of modern public and commercial buildings, it has become an attractive center of an altogether beautiful village. (See fig. 43.)



FIG. 44.—At Primghar, Iowa, the county courthouse occupies the central square

**A COUNTY COURTHOUSE OCCUPIES CENTRAL SQUARE OF VILLAGE—
PRIMGHAR, IOWA**

Courthouses in practically all sections of the country have often been of good design and have been given a conspicuous place in the town plan, frequently occupying the center of a public square. When the new courthouse of O'Brien County, Iowa, was erected in 1916 it was located on the site of the old one, on the most prominent central square of the county seat, a village of less than 1,000 population. The limestone building cost \$165,000 and is a well-equipped, modern county office and court building. On the four streets around this square the main business houses have been placed, the whole making a distinctive civic center. (See fig. 44.)

The ground improvements were planned and supervised by a trained horticulturist. The plantings consist of elm and maple trees and a variety of shrubs. The purchase and planting of trees and shrubs, building of walks, and preparation of grounds cost \$1,300, paid by the county.

A FINE COURTHOUSE ON A WESTERN PRAIRIE—LAKE ANDES, S. DAK.

The courthouse at Lake Andes, S. Dak., shows that the love for beautiful things was not absent from the nature of our western pioneers, but was merely held in abeyance while the more pressing need of subduing a continent was in progress. The country about it is still sparsely settled, for the population of the county, with an area of 1,134 square miles, is little over 16,000, and is given over almost exclusively to farming. No village has over 900 of population; that of the county seat is 867.

As soon as these farmers had overcome primitive conditions, they began the construction of a county courthouse. With rare foresight the planning of both building and grounds was put in the hands of those who felt that this permanent structure, occupying a rise of ground in a conspicuous position in the county seat, should be built along good architectural lines. It should be surrounded by well-laid-out and well-kept grounds, so as to have a compelling effect upon con-

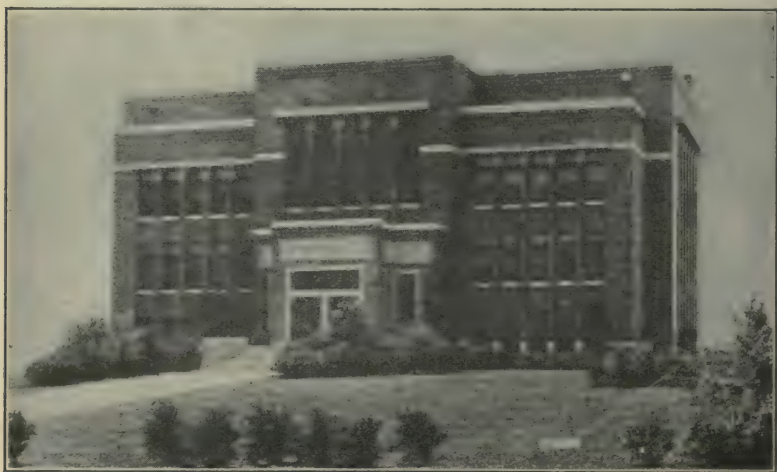


FIG. 45.—The county courthouse in a western prairie village. Lake Andes, S. Dak.

structive efforts in the whole county which was just finishing its temporary pioneer existence and entering upon its permanent home life. (Fig. 45.)

A TOWN HALL AND A GRANGE HALL, WELL DESIGNED AND WELL LOCATED—PETERSHAM, MASS.

Although the same consideration has not been given to the designing and placing of town halls that has been given to county courthouses, there are outstanding exceptions to this rule. Town halls should represent the good taste, the dignity, the power and wealth of the town as no other buildings do, and they stand in the same relation to the town that the courthouse does to the county; therefore it would seem that equal attention should be given to design and location.

The town hall at Petersham, Mass., a town founded in 1733, is a striking example in many ways. It was built in 1850 and cost about

\$7,500. In addition to its stately colonial design, including a famous dome, it has an excellent location on the common. The grange hall also has a colonial front and position on the common, across the street from the town hall. (See Fig. 46.) The building, occupied by the grange since 1875, has lodge room, kitchen, and dining room to serve its 128 members.

The common itself is conspicuously beautiful and is surrounded by civic and trade buildings of exceptional merit, including three churches, school, library, hotel, grange hall, post office, and store buildings—all well placed in good settings, and the whole forming a civic center.

The town, with a population of 642, engaged principally in farming, has an active village-improvement society organized in 1870



FIG. 46.—Well-placed civic buildings at Petersham, Mass. Town hall, right; Grange Hall, left

with about 75 members including the selectmen. This society has much to do with the beauty, cleanliness, and orderliness of the town.

A SCHOOL BUILDING THAT ATTRACTS—FREEHOLD, N. J.

Monmouth County, N. J., has frequently been a competitor for the honor of being the richest agricultural county in the country. Freehold, the county seat, is largely an agricultural town. Most of the business men and the majority of the residents are or have been engaged in farming.

Their especial pride is their beautiful high school, located on the main street in the center of the town, its curriculum linked up with farming, and its architecture and grounds forming a most attractive spot (fig. 47).

The broad desire to associate the practical and convenient with the beautiful in education, and the need of specimens of trees and

flowers for classroom work, influenced the plan made by the teachers and officials. The local florist, a retired farmer, planned the grounds and supervised the work. Among the plantings are such trees as linden, oak, catalpa, flowering cherry, Japanese maple, weeping birch, beech, mulberry, cypress, dwarf Norway maple, fir, Japanese spruce, blue spruce, Japanese cypress, several varieties of arbor vitae, and there are many varieties of shrubs and flowers. The cost of the plantings was \$400. Connected with the school is a small greenhouse for the use of classes in agriculture, which has become a commercial proposition, the profits going to the school.



FIG. 47.—A schoolhouse that attracts. Freehold, N. J.

**A MIDDLE WEST VILLAGE LIBRARY ASSOCIATES PLANTING WITH BOOKS—
ARMADA, MICH.**

As early as 1901 the country and village people of Armada, Mich., had determined to have a public library and had voted almost unanimously at a township election to tax themselves for this purpose. The first books purchased did not have a permanent home but were kept in various stores until the last one burned.

About 1913 a professor from the State university delivered a lecture in the village under the auspices of the village-improvement club, on the subject of landscape gardening. Among the auditors was a retired farmer whose son was working his farm on shares, both graduates of the State agricultural college. The president and a majority of the township board were also farmers.

As a result of the lecture the retired farmer pictured for the future an adequate free public library available for rural people, housed in a well-designed building with an attractive setting and background, which should be a social center. The library board agreed to his plans.

The township library tax amounted to about \$1,000 a year for the purchase of books and the building and maintenance of a library. As this method was slow, the librarian appealed to the Carnegie Foundation for funds. Small as the village was, the zeal and earnestness of these rural people and their willingness to tax themselves prevailed, and \$8,000 was allotted by the foundation for the building itself. The township tax was applied to the purchase of a lot, to books and furniture, and, after completion, to maintenance purposes.

When the library board received the building from the contractors it was surrounded by a chaos of stones, rubbish, and barren clay. As no funds were available for improving the grounds, a community campaign was initiated. A landscape architect at the State university prepared ground plans free of charge, and a farmers' grading and planting bee was held. (See fig. 48.) Actual money spent for improvement was only \$150, largely for elm trees, shrubs, and vines.



FIG. 48.—A country village library—at once substantial and beautiful. Armada, Mich.

When completed, children from their savings purchase pieces of furniture and the leading men of the community carried the 1,800 books and the furniture to the new building.

The library collection, an office, and a museum occupy the first floor. In the ground floor are the assembly room, furnished with piano and stereopticon, a magazine room, and toilets. The grounds are 120 by 100 feet, and are cared for by a retired farmer at little expense.

In addition to the library service to village and country, the assembly room is used as a meeting place by four farmers' organizations, the school board, the women's clubs, the town association, and by other clubs for public gatherings. Since the grounds were completed the buildings have become the pride of the town, the high school grounds and those of many dwellings have been planted, and the secretary of the board is constantly in receipt of requests for information and advice from other towns.

A MUNICIPAL HOSPITAL IN AN UNUSUAL SETTING—CANBY, MINN.

This public hospital, owned by a town of 1,700 inhabitants, is located two blocks from the main business corner, but is well back from the street. It is in a quiet setting of smooth, well-shaded green lawn and has a deep-shaded veranda. (See fig. 49.) If health is influenced by environment, early improvement might well be expected in the condition of patients of this hospital, because of the tranquil surroundings and the freedom from distracting noises.

The building itself was a gift; but it was repaired and furnished and the grounds were enlarged and improved through receipts from general voluntary contributions, a stimulating campaign being carried out by citizens to launch the enterprise.



FIG. 49.—Health in attractive surroundings. Canby, Minn., municipal hospital

Successful municipal operation was difficult at first, as the only support the hospital received from the county government was actual payment for county charges at the rate of \$1 per day together with the \$1,000 paid by the county for this contract. Now, however, it is self-sustaining, under the management of the town council through a hospital committee.

A WELL-PLACED COMMUNITY CENTER ADDS TO AN OTHERWISE BEAUTIFUL VILLAGE—WAVERLY, PA.

The farming village of Waverly, Pa., already possessed many good planning features, with its curving roads and streets following the physical contour of the country, its inviting road gateways, the clean fringe about the town and attractive farmsteads and gardens, the neat public and private buildings on broad lawns, and the wealth of well-placed trees.

The airplane view (see title page) shows that the community building and public playground have been placed in the center of the village on the main street, a position in keeping with their nature. The building occupies the center of a 2-acre space, is placed well back from the street, and its generous proportions are emphasized and set off by wide, open lawns. A few well-placed trees frame the grounds. Tennis courts, wading pool, and other recreation features are located with a view to symmetry.

The well-appointed building has in its basement bowling alleys, pool room, barber shop, men's lavatory and showers. On the first floor are the post office, canteen, reading-room, sun-parlor, lounge, reception room, assembly hall with its moving picture booth, and women's showers. On the second floor are the public library including its radio set, and the private apartment of the secretaries. The house supports a trained nurse for the village and farming community, a free kindergarten, and art, handiwork, dramatic, sewing, basketry, and playground classes, and is the headquarters of the town supervisors, the school board, the grange, the parent-teachers association and the boy scouts. It is also the center for elections and for school commencements and other exercises.

This plant was given to the people of Waverly, but there were many architectural and planning features involved, the solution of which should be of value to other towns and communities of even more than 500 population.

CONCLUSION

These examples of successful village planning are taken largely from villages of the usual rural type. In all of these planning projects difficulties were encountered and obstacles overcome, and the resulting benefits showed that the efforts were well worth while. It is hoped that this recital of what has actually been accomplished by village people in making village life more agreeable and satisfying and of the ease with which the work was done, will demonstrate (1) that such work is needed both for the people who live in villages and for the farm people who use the villages; (2) that it is never too early or too late to begin; (3) that it is often the economical thing to do; (4) that the expense is not prohibitive; (5) that results are commensurate with costs; (6) that the present and future should be treated as a whole but that plans should be flexible and subject to change; (7) that both fixed original planning and spontaneous natural planning have their value; and (8) that profitable and wholesome growth of villages and of community social life can evolve only along well-planned and well-ordered lines.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

January 16, 1925

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This bulletin is a contribution from

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Ind

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1442

STORAGE OF SWEET POTATOES



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
BULLETIN 970

THE STORAGE OF SWEET POTATOES is a sound economic practice which stabilizes the industry and makes the crop available over the greater portion of the year.

Satisfactory storage is dependent upon sweet potatoes that are well matured and carefully handled; moreover, they must be cured after being placed in the house and kept at a uniform temperature while in storage.

A substantial and satisfactory house for the storage of sweet potatoes can be built at moderate cost. If some existing building is available it is usually possible to alter it so as to make it suitable for this purpose.

This bulletin is a revision of and supersedes Farmers' Bulletin 970, "Sweet-Potato Storage."

Washington, D. C.

Issued February, 1925

STORAGE OF SWEET POTATOES¹

By H. C. THOMPSON, formerly *Horticulturist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry*

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IMPORTANCE OF SWEET-POTATO STORAGE

SWEET-POTATO STORAGE is a sound economic practice which makes the product available over a large portion of the year and in many cases obviates the necessity of selling the crop as soon as harvested, when prices are often low.

According to available statistics, more than 3,000 commercial sweet-potato storage houses are in use throughout the producing regions of the country. These have a capacity of about 12,000,000 bushels, a quantity sufficient to have a stabilizing effect on the industry and to make this nutritious vegetable available when it can not be supplied directly from the fields.

ESSENTIALS OF GOOD STORAGE

To keep sweet potatoes in good condition they must be (1) well matured before digging, (2) carefully handled, (3) well dried or cured after being put in the house, and (4) kept at a uniform temperature after they are cured.

The grower can judge when his sweet potatoes are ripe by breaking or cutting one of them and leaving it exposed to the air for a few minutes. The cut or broken surface dries if it is mature, but the surface remains moist if it is not ready to be dug. In regions where early frosts occur the potatoes should be dug about the time the first hard frost is expected, regardless of their stage of maturity.

The second essential, careful handling, should be observed in digging, gathering, hauling, and unloading. Sweet potatoes should be sorted in the field and gathered in padded baskets or boxes to prevent bruising or breaking the skin. The baskets or boxes should be loaded on the wagon, hauled to the storage house, and the potatoes carefully placed in the bins. When they are to be hauled very far, a wagon with bolster springs should be used. Sweet potatoes should

¹ The plans and lists of materials presented were prepared by the Bureau of Public Roads of the United States Department of Agriculture.

never be thrown from one row to another, loaded loosely into a wagon body, or hauled in bags, because any such practice will bruise them and afford an opportunity for disease to enter.

The third and fourth essentials, thorough drying and a uniform temperature, may be secured in a storage house where artificial heat can be supplied. The house must be constructed in such a way that it can be thoroughly ventilated when necessary and yet be made nearly air tight in cold weather. These requirements are provided in the types of houses described in this bulletin.

It is good economy to build a substantial sweet-potato storage house, because it will last longer and require less attention than a cheap, poorly constructed one. It would be possible to keep the potatoes in a cheaper and less carefully constructed house, but the attention required and the additional fuel used would soon exceed

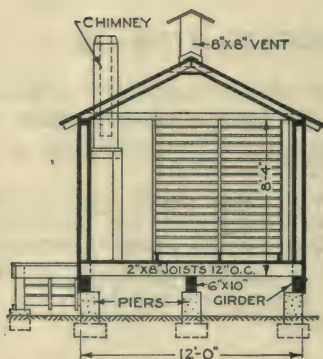


FIG. 1.—Section through a sweet-potato storage house, size 12 by 16 feet, having a capacity of 400 to 500 bushels in crates or 450 to 500 bushels in bulk, showing arrangement of bins

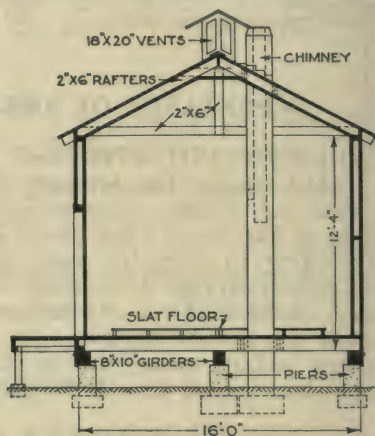


FIG. 2.—Section through a sweet-potato storage house, size 16 by 29½ feet, having a capacity of about 1,000 bushels in crates, showing various structural details

the cost of the extra labor and material necessary for building the better one. The chances of loss in a poorly built house are much greater than in one that is well built.

CONSTRUCTION OF SWEET-POTATO STORAGE HOUSES

Sweet-potato storage houses may be built of wood, brick, hollow tile, cement, or stone. Wooden houses are preferable, because they are usually cheaper and are easier to keep dry than the other types. It is difficult to keep moisture from collecting on the walls of a cement, stone, or brick house. Where such houses are built they should be lined with lumber, so as to keep the air in the house from coming in contact with the masonry walls. It is best to build sweet-potato storage houses on foundations that allow a circulation of air under them. The "dugout," or house built partly underground, is not satisfactory for storing sweet potatoes in the South, because it is practically impossible to keep this type of house dry, and moisture in the storage house will cause the crop to rot.

The foundation of the storage house may be in the form of piers or solid walls and should be of such a height that the floor is about on the level of the bottom of the wagon bed, while the footings should be carried below the frost line or to solid ground. Girders 6 by 10 by 12 inches in size are usually placed on the piers.

Where cement, brick, or stone foundation walls are built, they should extend 18 to 20 inches above the ground level, and plates 2 inches thick and 8 inches wide should be placed on the wall. In using walls for the foundation it is necessary to provide means for ventilation under the house. This can be done by placing small windows in the foundation every 10 to 12 feet. Even where solid outside foundation walls are used it is generally necessary to use piers for the center supports, as shown in Figures 1, 2, 3, 4, and 5.

The principles of constructing storage houses of various sizes are very much the same; therefore, only one, the 12 by 16 foot house, will be described.

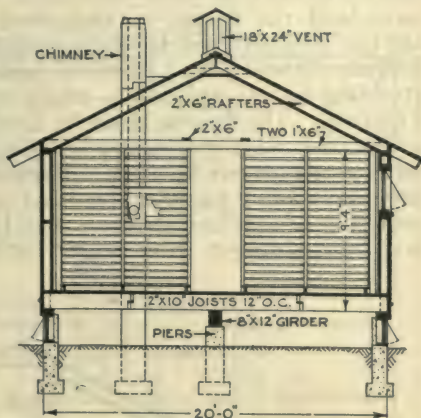


FIG. 3.—Section through a sweet-potato storage house, size 20 by 40 feet, having a capacity of 2,000 bushels in crates or 2,500 bushels in bulk, showing structural details

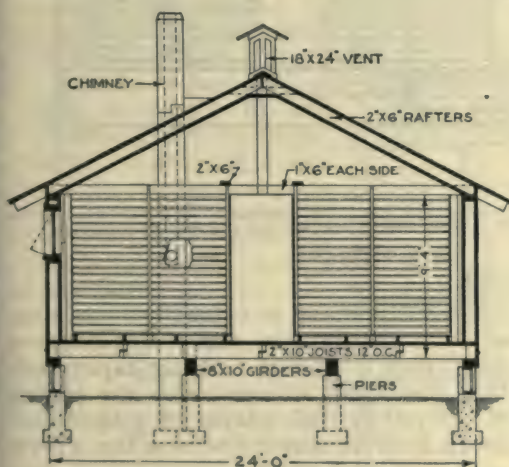


FIG. 4.—Cross section of a sweet-potato storage house, size 24 by 50 feet, having a capacity of 4,000 bushels in crates or 5,200 bushels in bulk, showing the arrangement of bins and other structural details

For this small storage house, having a capacity of 400 to 500 bushels, build three rows of piers, one row under each side and one under the center of the house. Girders 6 by 10 inches in size are placed on the piers and on these 2 by 8 inch joists, spaced 12 inches apart from center to center. The walls of the storage house are made by setting 2 by 4 inch studs on the girders every 2 feet and nailing them to the floor joists. On the outside of the studs 1 by 6 inch boards are nailed diagonally to brace the wall; over these a layer of

heavy building paper is tacked and matched siding then put on. A layer of 1 by 6 inch boards is nailed on the inside of the studding, then a layer of building paper, and over this matched boards. In

the lower South the first layer of boards on the inside of the studding may be omitted so far as the control of temperature is concerned, but in regions of high humidity (near the seacoast) it is deemed advisable to use four layers of boards, two on the inside and two on the outside of the frame, as suggested above. The tighter the walls, the less difficulty will be encountered in controlling both temperature and moisture. Two 2 by 4 inch pieces should be placed on top of the studding for eave plates, to which the rafters are nailed, as shown in Figure 2. The floor is made by laying 1 by 6 inch sheathing over the joists, then a layer of heavy building paper, and over this 1 by 4 inch tongue-and-groove flooring. The roof sheathing may be covered with shingles, roofing paper, galvanized iron, or any other kind of roofing material; but galvanized iron is to be preferred, because it is durable and lessens danger from fire. Use 2 by 4 inch scantling for rafters,

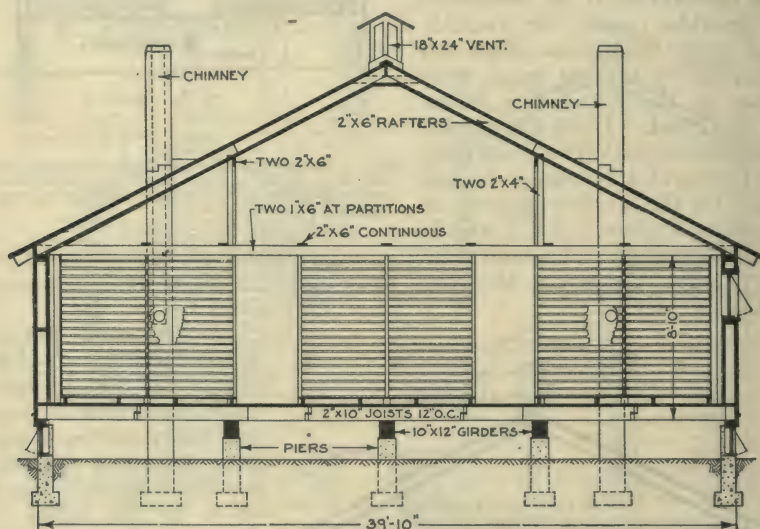


FIG. 5.—Cross section of a sweet-potato storage house, size 39 feet 10 inches by 100 feet 10 inches, having a capacity of 12,000 bushels in crates or 15,000 bushels in bulk, showing arrangement of bins and other structural details

and make the roof tight to keep out the cold. The rafters should be cut to fit over the plate at the lower end and to fit snugly against the ridgepole at the upper end. On the outside of the rafters put a layer of 1 by 6 inch sheathing, then a layer of building paper, then another layer of 1 by 6 inch sheathing, and over this the roofing material. On the inside of the rafters nail a layer of 1 by 6 inch sheathing, then a layer of heavy building paper, and over this a layer of matched boards.

The sides of the building should be tied together to prevent spreading. This can be done by nailing 2 by 4 inch pieces to the plates or to the lower ends of the rafters. It would be an advantage to have these pieces over the bin support.

The space between the walls should be left open, because any material used to keep out the cold will absorb moisture. Many storage houses have been built with sawdust, shavings, or similar

material between the walls, but this practice should never be followed. Sawdust will take up moisture and when once wet will never dry out. This moisture will keep the house damp and cause the walls to rot. The air space is a good insulator if the walls are made tight, and they will be tight if the plans illustrated in this bulletin are followed.

Thorough ventilation is necessary in a storage house. This is provided by means of windows, doors, and ventilators in the floor and through the roof, as shown in the various text figures in this bulletin. The openings in the floor around the stove prevent overheating the potatoes near the stove. The windows and doors must be made so as to close tightly to keep out the cold. All windows should be made to open from the outside or be fitted with devices for opening them from the inside. Where windows filled with glass are used, outside shutters are put on, as shown in Figure 6, and these should be well padded. Some of the windows should be made of glass, so as to admit light without letting in cold air, as it is necessary to have light when working in the house, and in cold weather the house should not be kept open. All of the openings must be made so they can be closed quickly and tightly whenever necessary. The ventilators in the roof should extend through the ceiling, so as to carry out the warm air as it arises. The location and size of the floor and ceiling ventilators are determined by the size of

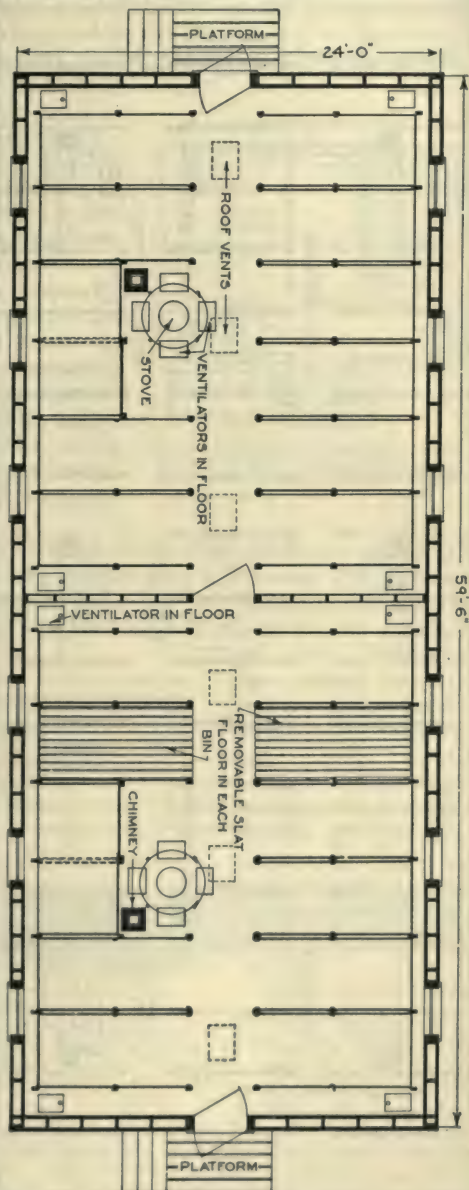


FIG. 6.—Floor plan of a sweet-potato storage house, size 24 by 59½ feet, having a capacity of 4,000 bushels in crates or 5,200 bushels in bulk

The 12 by 16 foot 400 to 500 bushel house can be suitably ventilated by the

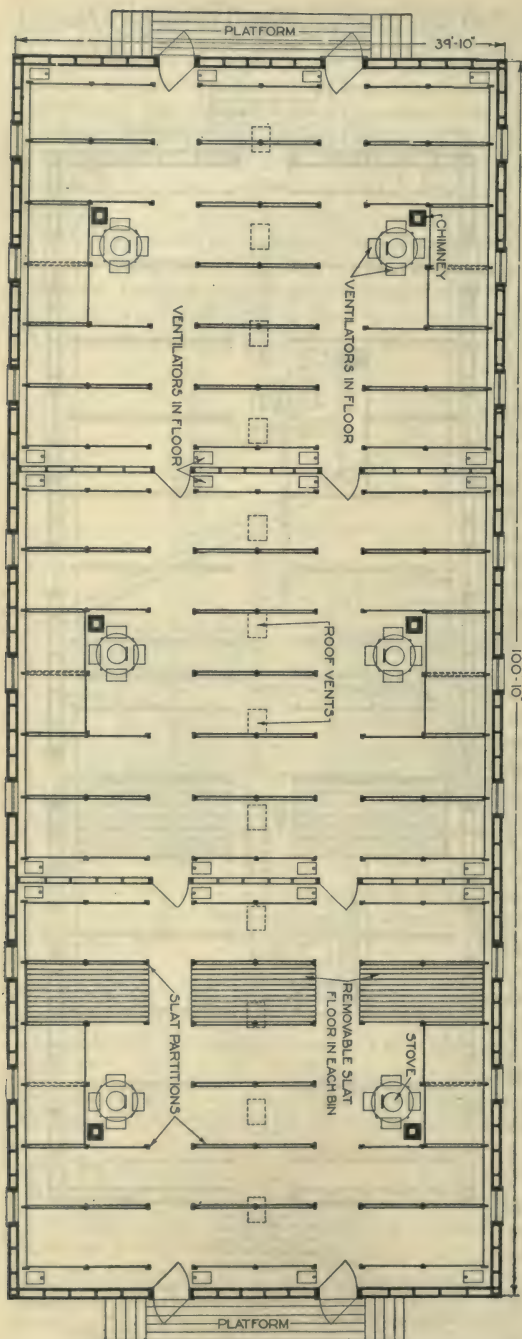


Fig. 7.—Floor plan of a sweet-potato storage house, size 39 feet 10 inches by 100 feet 10 inches, having a capacity of 12,000 bushels in crates or 15,000 bushels in bulk

use of two 10 by 12 inch floor ventilators near the stove, one 12 by 18 inch floor ventilator in each corner, and three 12 by 12 inch ceiling ventilators. The 16 by 29½ foot 1,000-bushel house is equipped with three 10 by 12 inch floor ventilators around the stove and six 12 by 18 inch floor ventilators, one in each corner and one along each side wall near the middle of the building. Two 18 by 20 inch roof ventilators are used in a house of this size. The size and location of the floor ventilators in the larger houses are shown in Figures 6 and 7. Complete details covering these plans and specifications may be had upon application to the Division of Rural Engineering, Bureau of Public Roads, United States Department of Agriculture.

The arrangement of the interior of the house depends upon the methods of storage used. Some growers store the potatoes in boxes, crates, baskets, or hampers, while others store in bins. The smaller containers are to be preferred to bins where it is practicable to use them, because they eliminate considerable handling and reduce the amount of decay. Many growers store in the hampers that are to be used

for marketing the potatoes. This is a satisfactory plan, as it requires no outlay of money for storage receptacles, and the packages for shipping must be provided in any event if the crop is to be marketed. Some growers have bushel boxes made for the special purpose of storing sweet potatoes, while others employ various types of used crates. With any type of package it is necessary to provide means for ventilation. A false slatted floor is often made by nailing 1 by 4 or 1 by 6 inch boards to 2 by 4 inch scantling. An inch space should be left between the boards to allow the air to circulate. A little space should be left between the stacks of boxes, baskets, crates, or hampers. Where these smaller containers are used, especially when the same package is employed for shipping the crop, it is much easier to disinfect the storage house by spraying than when bins are used. Another advantage in using them is that when decay sets in it usually spreads only to the potatoes in the single package, whereas in the bin it might spread throughout the entire pile.

If bins are to be used, the interior of the storage house should be arranged for convenience in handling the sweet potatoes. A passageway about $3\frac{1}{2}$ to 4 feet in width is usually left between the rows of bins or between the wall and the bins in a house with only one row of bins. Sufficient open space must be left to allow access to the ventilators in the corners of the storage rooms. Satisfactory arrangements of passageways and bins for various-sized houses are shown in the floor plans of Figures 6 to 10.

The bins are made as follows:

For the corner and middle supports, 2 by 4 inch scantlings are set up, the lower end nailed to the floor and the upper end to the crosspieces used for tying the sides together. Over the supports 1 by 4 inch boards are nailed, leaving a 1-inch space between them. The ends of the bins parallel with the outside wall of the house must be built first, because there is not room enough to work between the bin and the outside wall. In making the slat floors, 2 by 4 inch scantlings are cut to go across the bin and placed on edge, one near each end and one or two equally spaced between. To these 1 by 4 or 1 by 6 inch boards are tacked, leaving a 1-inch space

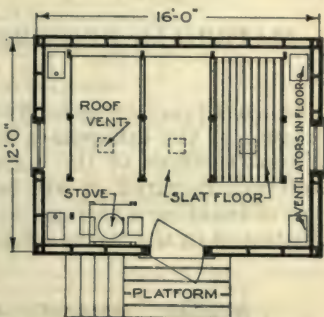


FIG. 8.—Floor plan of a sweet-potato storage house, size 12 by 16 feet, having a capacity of 400 to 500 bushels in crates or 450 to 500 bushels in bulk

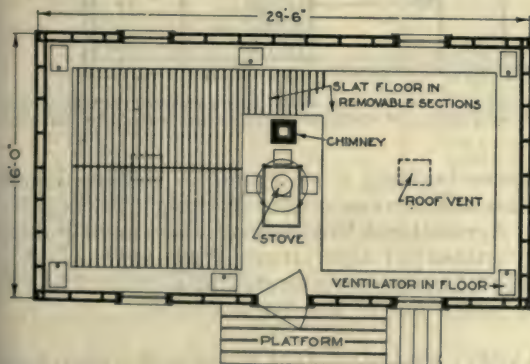


FIG. 9.—Floor plan of a sweet-potato storage house, size 16 by 29½ feet, having a capacity of about 1,000 bushels in crates, showing arrangement of floor ventilators, roof vents, chimney, and other structural details

to the floor and the upper end to the crosspieces used for tying the sides together. Over the supports 1 by 4 inch boards are nailed, leaving a 1-inch space between them. The ends of the bins parallel with the outside wall of the house must be built first, because there is not room enough to work between the bin and the outside wall. In making the slat floors, 2 by 4 inch scantlings are cut to go across the bin and placed on edge, one near each end and one or two equally spaced between. To these 1 by 4 or 1 by 6 inch boards are tacked, leaving a 1-inch space

between them. If left loose the slat floor racks can be taken out when the house is cleaned and disinfected during the summer. The size of the bins will depend somewhat on the arrangement and size of the house, but it is not advisable to make them more than 5 feet wide, 6 to 8 feet deep, and 10 to 12 feet long. There should be a 6 to 12 inch space between the walls and the bins to permit air to circulate. It is necessary to slat up both sides of the scantlings between the bins in order to leave an air space between the potatoes in the different bins. The construction here described allows a 4-inch space between the bins, a 4-inch space under the bins, and over 6 inches between the bins and outside walls.

MATERIALS REQUIRED FOR HOUSES OF DIFFERENT SIZES

It is not practicable to give the cost of a sweet-potato storage house, because of the differences in the price of materials and labor in the various sections of the country. However, given the quantities of materials required, it will be easy for one to obtain estimates on the cost of building a storage house. Quantities are given for the houses illustrated in the various figures.

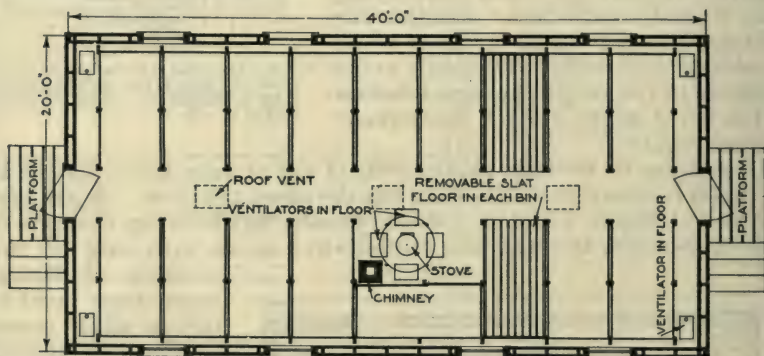


FIG. 10.—Floor plan of a sweet-potato storage house, size 20 by 40 feet, having a capacity of 2,000 bushels in crates or 2,500 bushels in bulk, showing location of ventilators, stove, arrangement of bins, and other details

Anyone who contemplates building a sweet-potato storage house after the plans shown in this bulletin can obtain working drawings by writing to the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C., for any of the plans for the five houses illustrated in Figures 1 to 11. In requesting plans, state which one of the five is desired.

MATERIALS REQUIRED FOR A SWEET-POTATO STORAGE HOUSE 12 BY 16 FEET, HAVING A CAPACITY OF 400 TO 500 BUSHELS IN CRATES OR 450 TO 500 BUSHELS IN BULK

Quantities are for dimensions shown on the drawing (8-foot studs) and must be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

If the potatoes are to be stored in bulk, the items marked with a star (*) are to be omitted. If storage is to be in crates, the stud walls should be 11 feet 6 inches high (instead of 7 feet 8 inches, as shown in the drawings), the items marked with a dagger (†) are to be omitted, and those marked with a star (*) are to be included.

Concrete.*Mixture—*

One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel.

Quantities—

Cement, 6 sacks; sand, 20 cubic feet; gravel, 31 cubic feet; or, cement, 6 sacks; bank-run gravel 1½ cubic yards.

Chimney.*Mixture for mortar—*

One part Portland cement, three parts sand.

Quantities—

Cement, 1 sack; sand, 4 cubic feet; bricks, 190; 1 terra-cotta thimble, 6-inch; 6 linear feet 8 by 8 inch terra-cotta flue lining.

Lumber.*Girders—*

Two 6 by 10 inches by 12 feet.

Three 6 by 10 inches by 16 feet.

Joists—

Seventeen 2 by 8 inches by 12 feet.

Studs—

†Nineteen 2 by 4 inches by 16 feet.

*Thirty-eight 2 by 4 inches by 12 feet.

Plates—

Six 2 by 4 inches by 16 feet.

Six 2 by 4 inches by 12 feet.

Ties—

Four 2 by 4 inches by 12 feet.

Rafters—

Eleven 2 by 4 inches by 16 feet.

One 1 by 6 inches by 18 feet (ridge).

Sheathing (includes 20 per cent waste)—

2,084 feet board measure 1 by 6 inches.

*530 feet board measure 1 by 6 inches.

Drop siding (includes 20 per cent waste)—

615 feet board measure 1 by 6 inches.

*265 feet board measure 1 by 6 inches.

Flooring (tongue and groove, includes 25 per cent waste)—

1,000 feet board measure 1 by 4 inches.

*290 feet board measure 1 by 4 inches.

**Slat floor—*

Four 2 by 4 inches by 16 feet.

Thirty-five 1 by 4 inches by 14 feet.

Platform—

Three 2 by 4 inches by 12 feet.

One 2 by 8 inches by 14 feet.

Three 2 by 8 inches by 12 feet.

One 4 by 4 inches by 6 feet.

One 2 by 12 inches by 12 feet.

Two 1 by 10 inches by 14 feet.

Trim (surfaced 4 sides)—

†Five 1½ by 4½ inches by 18 feet.

One 1½ by 4½ inches by 14 feet.

*Ten 1½ by 4½ inches by 12 feet.

Two 1 by 6 inches by 16 feet.

Two 1 by 8 inches by 16 feet.

Two 1 by 8 inches by 12 feet.

Two 1 by 6 inches by 18 feet.

Seventy linear feet 1½ by 2½ inches (drip molding).

Lumber—Continued.*Ventilators in roof (surfaced 4 sides)—*

Three 1 by 12 inches by 14 feet.

†Bins—

Six 2 by 4 inches by 16 feet.

Three 2 by 4 inches by 12 feet.

Two 2 by 2 inches by 16 feet.

Six 1 by 2 inches by 16 feet.

Thirty-four 1 by 4 inches by 12 feet.

Sixty-five 1 by 4 inches by 14 feet.

Chimney platform—

†One 2 by 6 inches by 12 feet.

*Two 2 by 6 inches by 10 feet.

Roof covering.

As desired, for 290 square feet.

Building paper.

20 squares; *2 squares.

Miscellaneous.

Two single sash and frames for 6 lights, 9 by 12 inch glass, 4-inch studs.

One No. 2 glazed door, 3 by 7 feet, 6 lights, 8 by 10 inch glass.

One frame for glazed door, 3 by 7 feet, 4-inch studs.

Three pairs 2 by 2 inch galvanized hinges.

Two pairs 2½ by 2½ inch galvanized hinges (windows).

One pair 3½ by 3½ inch loose-pin butts (glazed doors).

One pair 6-inch galvanized T hinges (battened doors).

Four pairs 4-inch galvanized T hinges (shutters).

Two pairs chain bolts, chains, and keepers (windows).

Three pairs ¾ by 2½ inch sash centers (ventilators).

Four pairs ¾ by 3 inch bolts, with 4-inch ring (floor ventilators).

Nine pairs ¾ by 18 inch bolts, nuts, and washers (foundation).

Two wrought-steel straps ¼ by 2½ by 18 inches (platform posts).

Four lag screws ¼ by 3 inches (platform posts).

Thirty-six linear feet ¼-inch rope.

Four linear feet galvanized flashing 12 inches wide (around chimney).

Twelve linear feet galvanized flashing 8 inches wide (roof ventilators).

Fourteen square feet ¼-inch mesh wire cloth (vents).

Four window-spring bolts.

Two chains 8 inches long, with screw eyes and hooks (windows).

One sheet-iron pad and heat screen, as detailed.

Latches for doors and shutters, as desired.

Nails.

Four pounds 20-penny, 17 pounds 10-penny, 85 pounds 8-penny, 10 pounds 6-penny, 3 pounds 8-penny finishing.

Paint.

Three outside coats, 4 gallons.

MATERIALS REQUIRED FOR A SWEET-POTATO STORAGE HOUSE 16 BY 29½ FEET, HAVING A CAPACITY OF ABOUT 1,000 BUSHELS IN CRATES

Quantities are for dimensions shown on the drawings. Footings should bear on solid ground. If piers are built to a greater height, they should be increased in cross-sectional area.

Concrete.*Mixture—*

One part Portland cement, three parts sand, and five parts gravel or broken stone.

Quantities—

Cement, 12 sacks; sand, 1½ cubic yards; gravel, 1½ cubic yards.

Chimney.*Quantities—*

Cement, 3 sacks; sand, 1½ cubic yard; bricks, 730; 1 terra-cotta thimble, 5-inch; 12 linear feet 8 by 8 inch terra-cotta flue lining; 4 linear feet galvanized flashing 18 inches wide.

Lumber.*Girders—*

Six 8 by 10 inches by 16 feet.

Two 4 by 10 inches by 16 feet.

Lumber—Continued.*Joists—*

Twenty-six 2 by 8 inches by 16 feet.

150 linear feet 1 by 3 inches (bridging).

Studs—

Sixty-four 2 by 4 inches by 12 feet.

Horizontals—

Eleven 2 by 4 inches by 10 feet.

Braces—

Eight 2 by 4 inches by 12 feet.

Plates—

Twelve 2 by 4 inches by 16 feet.

Ties—

Two 2 by 6 inches by 16 feet.

Rafters—

Thirty-two 2 by 6 inches by 10 feet.

Two 1 by 8 inches by 16 feet (ridge).

Lumber—Continued.*Collar beams—*

Nine 2 by 6 inches by 8 feet.

Platform—

One 2 by 4 inches by 10 feet (posts).

Twelve 2 by 4 inches by 10 feet.

One 2 by 8 inches by 14 feet.

Five 2 by 8 inches by 10 feet.

One 2 by 10 inches by 10 feet (steps).

One 2 by 10 inches by 16 feet (steps).

Trim (surfaced 4 sides)—

Four 2 by 6 inches by 10 feet (rafters).

Six 1 by 8 inches by 16 feet (base).

Eight 1 by 4½ inches by 12 feet (corner boards).

Four 1 by 6 inches by 16 feet (saddle boards).

Eight 1 by 4½ inches by 8 feet (windows and doors).

111 linear feet 1½ by 2½ inches (drip molding).

Ventilators—

Four 1 by 10 inches by 12 feet.

Two 1 by 6 inches by 10 feet (roofing boards).

Four 1 by 3 inches by 16 feet.

4 pieces wire cloth ¼-inch mesh, 20 by 15 inches.

12 linear feet galvanized flashing 18 inches wide.

2 pairs 2¼ by ¾ inch sash centers.

2 screw eyes.

Sheathing (includes 20 per cent waste)—

5,500 feet board measure 1 by 6 inches.

Flooring (tongue and groove, includes 25 per cent waste)—

2,500 feet board measure 1 by 4 inches.

Drop siding (includes 20 per cent waste)—

1,500 feet board measure 1 by 6 inches.

Lumber—Continued.*Slat floor—*

If slats over whole floor are desired, use these items: Seventeen 2 by 4 inches by 12 feet; sixty 1 by 4 inches by 12 feet.

If slats under edges of boxes are desired, use these items: 120 linear feet 2 by 4 inches; 18 pieces 1 by 4 inches by 12 feet.

Roof covering.

As desired, for 682 square feet.

Building paper.

4,600 square feet.

Miscellaneous.

16 pairs 2-inch galvanized butts.

1 pair butts (door).

1 pair 6-inch galvanized T hinges.

1 lock and latch (door).

Fasteners for shutters and windows.

Galvanized iron (floor under stove).

15 anchor bolts ¾ by 18 inches.

3 straps ¾ by ¼ by 12 inches.

6 lag screws ¾ by 3 inches.

Four 6-light sash, 9 by 12 inch glass, with frames and sills.

1 glazed door 3 by 7 feet, 6 lights 8 by 12 inch glass, with frame and sills.

12 linear feet galvanized wire cloth, ½-inch mesh, 18 inches wide.

Nails.

35 pounds 6-penny, 6 pounds 6-penny finishing, 200 pounds 8-penny, 40 pounds 10-penny, 3 pounds 20-penny.

Paint.

6 gallons.

MATERIALS REQUIRED FOR A SWEET-POTATO STORAGE HOUSE 20 BY 40 FEET, HAVING A CAPACITY OF 2,000 BUSHELS IN CRATES OR 2,500 BUSHELS IN BULK

This building is designed for the storage of potatoes in crates or in one tier of bins in which the potatoes may be loaded 6 feet high.

Quantities are for dimensions shown on the drawings (9-foot 4-inch studs) and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

If the potatoes are to be stored in bulk, the items marked with a star (*) are to be omitted. If storage is to be in crates, the stud walls should be 12 feet 4 inches high (instead of 9 feet 4 inches, as shown in the drawings), the items marked with a dagger (†) are to be omitted, and those marked with a star (*) are to be included.

Concrete.*Mixture—*

One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel.

Quantities—

Constituents	Walls	Piers
Cement.....	79 sacks.....	7 sacks.
Sand.....	8.7 cu. yds....	21 cu. ft.
Gravel.....	14.5 cu. yds....	34 cu. ft.
Or—		
Cement.....	79 sacks.....	7 sacks.
Bank-run gravel.	19 cu. yds....	1.8 cu. yds.

Chimney.*Mixture for mortar—*

One part Portland cement, three parts sand.

Quantities—

Cement, 3 sacks, *1 sack: Sand 10 cubic feet, *1½ cubic feet; bricks 700, *bricks 90; 1 terra-cotta thimble, 6-inch; 12 linear feet 8 by 8 inch terra-cotta flue lining, *4 linear feet.

Lumber.*Girders—*

Two 8 by 12 inches by 16 feet.

One 8 by 12 inches by 8 feet.

Sills—

Twenty-four 2 by 8 inches by 12 feet.

Studs—

†Twenty-six 2 by 4 inches by 18 feet (side).

*Fifty-four 2 by 4 inches by 12 feet (side).

*Four 2 by 4 inches by 10 feet (window).

*Twenty-four 2 by 4 inches by 12 feet (end).

†Four 2 by 4 inches by 12 feet (over windows).

Lumber—Continued.*Studs—Continued.*

†Twelve 2 by 4 inches by 18 feet (end).

One 2 by 4 inches by 16 feet (end).

Two 2 by 4 inches by 12 feet (end).

Four 2 by 4 inches by 10 feet (end).

One 2 by 4 inches by 14 feet (over doors).

Plates—

†Twenty-four 2 by 4 inches by 10 feet (side).

*Twelve 2 by 4 inches by 10 feet (end).

†Sixteen 2 by 4 inches by 10 feet (side).

*Eight 2 by 4 inches by 10 feet (end).

*Eight 2 by 4 inches by 10 feet (stops).

*Eight 2 by 4 inches by 10 feet (on top of ties).

Rafters—

Forty-four 2 by 6 inches by 14 feet.

Two 2 by 6 inches by 12 feet.

Two 1 by 6 inches by 12 feet (ridge).

Two 1 by 6 inches by 10 feet (ridge).

Six 2 by 4 inches by 14 feet (collar beams).

Joists—

Eighty-four 2 by 10 inches by 10 feet.

160 linear feet 1 by 3 inches (bridging).

*Eight 2 by 4 inches by 10 feet (bridging).

*Twelve 2 by 6 inches by 12 feet (ties and braces).

Sheathing (includes 20 per cent waste)—

2,568 feet board measure 1 by 6 inches (roof).

*830 feet board measure 1 by 6 inches.

1,032 feet board measure 1 by 6 inches (ceiling).

1,200 feet board measure 1 by 6 inches (inside walls).

1,344 feet board measure 1 by 6 inches (outside walls).

960 feet board measure 1 by 6 inches (subfloor).

1,344 feet board measure 1 by 5 inches (drop siding).

*420 feet board measure 1 by 6 inches (drop siding).

Lumber—Continued.

Flooring (tongue and groove, includes 25 per cent waste)—

- 1,075 feet board measure 1 by 4 inches (ceiling).
- 1,400 feet board measure 1 by 4 inches (walls).
- *440 feet board measure 1 by 4 inches (walls).
- 1,000 feet board measure 1 by 4 inches (floor).

Ventilators in roof (surfaced 4 sides)—

- Three 1 by 10 inches by 16 feet.
- Three 1 by 12 inches by 10 feet.
- 170 linear feet 1 by 3 inches.
- 24 linear feet 1 by 4 inches.
- One 1 by 10 inches by 12 feet (roof boards).
- One 1 by 10 inches by 8 feet (roof boards).
- One 1 by 8 inches by 12 feet (roof boards).
- One 1 by 8 inches by 8 feet (roof boards).

Trim (surfaced 4 sides)—

- Three 1½ by 4½ inches by 14 feet (doors).
- Eight 1½ by 4½ inches by 10 feet (windows).
- †Four 1½ by 4½ inches by 13 feet (corners).
- *Eight 1½ by 4½ inches by 10 feet.
- Four 1½ by 4½ inches by 14 feet (end fascia).
- Twelve 1 by 8 inches by 10 feet (baseboard).
- Four 1 by 6 inches by 12 feet (ridge).
- Four 1 by 6 inches by 10 feet (ridge).
- 150 linear feet 1½ by 2½ inches (drip molding).

Bins—

- †Twenty-nine 2 by 4 inches by 18 feet (studs).
- †Ten 2 by 2 inches by 18 feet (nailing strips).
- †Twenty 1 by 6 inches by 12 feet (ties at partitions).
- †Twenty 1 by 6 inches by 16 feet (ties at partitions).
- †Thirty-two 1 by 2 inches by 18 feet (cleats for loose boards).
- †Eight 2 by 6 inches by 10 feet (over bins).
- Eighteen 2 by 4 inches by 12 feet (under removable floors).
- †Four hundred 1 by 4 inches by 16 feet (side).
- Seventy-two 1 by 4 inches by 16 feet (removable floors).
- †One hundred and sixty-two 1 by 4 inches by 16 feet (loose slats).
- Eight 1 by 6 inches by 10 feet (battens for shutters and doors).

Screens (surfaced 4 sides, for foundation windows)—

- Three ¾ by 2 inches by 16 feet.

Platforms—

- Five 2 by 8 inches by 12 feet (sides and floor).
- One 2 by 8 inches by 14 feet (side).
- Two 2 by 12 inches by 12 feet (carriages).

Lumber—Continued.

Platforms—Continued.

- Two 4 by 4 inches by 12 feet (posts).
- Two 2 by 4 inches by 12 feet (nailing strips).
- Three 2 by 4 inches by 14 feet (joists).
- Two 2 by 10 inches by 14 feet (treads).

Roof covering.

As desired, for 1,700 square feet.

Building paper.

58 squares; *4 squares.

Miscellaneous.

- 6 cellar sash and frames for 3 lights, 8 by 10 inch glass.
- 8 single sash and frames for 6 lights, 9 by 12 inch glass (4-inch studs).
- 2 No. 2 glazed doors 3 by 7 feet, 6 lights, 8 by 10 inch glass.
- 2 frames for glazed doors 3 by 7 feet (4-inch studs).
- 22 pairs 2½ by 2½ inch galvanized hinges (stove-floor vents and sash).
- 2 pairs 3½ by 3½ inch loose-pin butts (glazed doors).
- 2 pairs 6-inch galvanized T hinges (battened doors).
- 16 pairs 4-inch galvanized T hinges (shutters).
- 3 pairs ¾ by 2½ inch sash centers (ventilators).
- 3 screw eyes in ventilator.
- 36 linear feet ¾-inch rope.
- 4 bolts, ¾ by 3 inches, with 4-inch rings (floor ventilators).
- 45 square feet ¼-inch mesh galvanized wire cloth (vents and foundation screens).
- 24 bolts, nuts, and washers ¾ by 18 inches (foundations).
- 6 linear feet galvanized-iron flashing 12 inches wide (around chimney).
- 30 linear feet galvanized-iron flashing 8 inches wide (roof ventilators).
- 4 wrought-steel straps ¼ by 2½ inches (platform posts).
- 8 lag screws ¼ by 3 inches (platform posts).
- 1 sheet-metal pad and heat shield, as detailed.
- 8 adjusting rods and fittings for windows, as detailed.
- Latches for doors, shutters, and foundation windows, as selected.

Nails.

- 2 pounds 30-penny, 10 pounds 20-penny, 30 pounds 10-penny, 300 pounds 8-penny, 100 pounds 6-penny, 10 pounds 8-penny finishing.

Paint.

Three outside coats, 8 gallons.

MATERIALS REQUIRED FOR A SWEET-POTATO STORAGE HOUSE 24 BY 59½ FEET, HAVING A CAPACITY OF ABOUT 4,000 BUSHELS IN CRATES OR 5,200 BUSHELS IN BULK

This building is designed for the storage of potatoes in crates or in one tier of bins in which the potatoes may be loaded 6 feet high.

Quantities are for dimensions shown on the drawings (9-foot 4-inch studs) and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

If the potatoes are to be stored in bulk, the items marked with a star (*) are to be omitted. If storage is to be in crates, the stud walls should be 12 feet 4 inches high (instead of 9 feet 4 inches, as shown in the drawings), the items marked with a dagger (†) are to be omitted, and those marked with a star (*) are to be included.

Concrete.

Mixture—

One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel.

Quantities—

Constituents	Walls	Piers
Cement.....	109 sacks.....	15 sacks.
Sand.....	12 cu. yds.....	1.5 cu. yds.
Gravel.....	20 cu. yds.....	2.6 cu. yds.
Or—		
Cement.....	109 sacks.....	15 sacks.
Bank-run gravel	24 cu. yds.....	3.3 cu. yds.

Chimneys.

Mixture for mortar—

One part Portland cement, three parts sand.

Quantities—

Cement 10 sacks, *1 sack; sand 1½ cubic yards, *1½ cubic feet; bricks 1,560, *bricks 180; 2 terra-cotta thimbles, 6-inch; 28 linear feet 8 by 8 inch terra-cotta flue lining, *6 linear feet.

Lumber.

Girders—

- Four 8 by 10 inches by 18 feet.
- Three 8 by 10 inches by 16 feet.

Sills—

- Twenty-eight 2 by 8 inches by 12 feet.

Studs—

- Sixty-two 2 by 6 inches by 18 feet.
- *Ninety 2 by 6 inches by 12 feet.
- *Twelve 2 by 6 inches by 14 feet (gable).

Lumber—Continued.*Studs—Continued.*

*Twelve 2 by 6 inches by 10 feet (window).

†Four 2 by 6 inches by 14 feet.

Plates—

*Fourteen 2 by 6 inches by 12 feet (bridging).

Fourteen 2 by 6 inches by 10 feet (stops).

Seven 2 by 6 inches by 12 feet (over doors and windows).

Twenty-eight 2 by 6 inches by 12 feet.

**Ties—*

Twelve 2 by 6 inches by 12 feet.

Nine 2 by 6 inches by 14 feet.

Rafters—

Sixty-two 2 by 6 inches by 16 feet.

Three 2 by 6 inches by 12 feet.

Six 1 by 6 inches by 12 feet (ridge).

Collar beams—

Eight 2 by 4 inches by 14 feet.

Joists—

Forty-eight 2 by 10 inches by 16 feet.

Twenty-four 2 by 10 inches by 18 feet.

400 linear feet 1 by 3 inches (bridging).

Sheathing (includes 20 per cent waste)—

11,220 feet board measure 1 by 6 inches.

*1,400 feet board measure 1 by 6 inches.

Flooring (tongue and groove, includes 25 per cent waste)—

6,500 feet board measure 1 by 4 inches.

*780 feet board measure 1 by 4 inches.

**Slat floor—*

One hundred 1 by 4 inches by 18 feet.

Twenty-two 2 by 4 inches by 16 feet.

Drop siding (includes 20 per cent waste)—

2,000 feet board measure 1 by 6 inches.

*600 feet board measure 1 by 6 inches.

Trim (surfaced 4 sides)—

Twelve $\frac{1}{2}$ by 4 $\frac{1}{2}$ inches by 10 feet.

*Eight $\frac{1}{2}$ by 4 $\frac{1}{2}$ inches by 10 feet.

†Four $\frac{1}{2}$ by 4 $\frac{1}{2}$ inches by 18 feet.

Four 1 by 6 inches by 16 feet.

Fourteen 1 by 8 inches by 12 feet.

160 linear feet 1 $\frac{1}{2}$ by 2 $\frac{1}{2}$ inches (drip molding).

Ventilators in roof (surfaced 4 sides)—

Six 1 by 10 inches by 16 feet.

Six 1 by 12 inches by 10 feet.

340 linear feet 1 by 3 inches.

48 linear feet 1 by 4 inches.

Three 1 by 10 inches by 12 feet (roof boards).

Three 1 by 8 inches by 12 feet (roof boards).

†Bins—

Five hundred and seventy-five 1 by 4 inches by 18 feet.

Ninety-five 1 by 4 inches by 16 feet.

Forty 2 by 4 inches by 18 feet.

Fourteen 2 by 2 inches by 18 feet.

Sixty-six 1 by 6 inches by 12 feet.

Forty 1 by 2 inches by 16 feet.

Eight 2 by 6 inches by 10 feet.

Two 2 by 6 inches by 18 feet.

Lumber—Continued.*Dividing partitions—*

†Ten 2 by 4 inches by 18 feet.

*Thirteen 2 by 4 inches by 12 feet.

*Six 2 by 4 inches by 14 feet.

†Five 2 by 4 inches by 12 feet (plates and bridging).

Two 2 by 4 inches by 14 feet (at ceiling).

Screens (for foundation windows)—

Six $\frac{3}{4}$ by 2 inches by 16 feet (surfaced 4 sides).

Platforms—

Six 2 by 4 inches by 12 feet.

Two 2 by 8 inches by 14 feet.

Six 2 by 8 inches by 12 feet.

One 4 by 4 inches by 12 feet.

Two 2 by 12 inches by 12 feet.

Four 2 by 10 inches by 14 feet.

Roof covering.

As desired, for 1,860 square feet.

Building paper.

103 squares; 11 squares.

Miscellaneous.

12 foundation sash and frames for 3 lights, 8 by

10 inch glass.

12 single sash and frames for 6 lights, 9 by 12

inch glass (6-inch studs).

2 No. 2 glazed doors, 3 by 7 feet; 6 lights, 8 by 10

inch glass.

2 frames for glazed doors 3 by 7 feet (6-inch studs).

32 pairs 2 $\frac{1}{2}$ by 2 $\frac{1}{2}$ inch galvanized hinges.

2 pairs 3 $\frac{1}{2}$ by 3 $\frac{1}{2}$ inch galvanized loose-pin butts.

3 pairs 6-inch T hinges (battened doors).

4 pairs 4-inch T hinges (shutters).

6 pairs $\frac{1}{8}$ by 2 $\frac{1}{4}$ inch sash centers.

8 bolts $\frac{1}{2}$ by 3 inches, with 4-inch rings (floor

ventilators).

50 linear feet galvanized flashing 8 inches wide

(roof ventilators).

16 linear feet galvanized flashing 12 inches wide

(around chimneys).

40 bolts, nuts, and washers, $\frac{1}{2}$ by 18 inches.

4 wrought-steel straps $\frac{1}{4}$ by 2 $\frac{1}{2}$ by 18 inches

(platform posts).

16 lag screws $\frac{1}{4}$ by 3 inches (platform posts).

6 screw eyes (in ventilator).

72 linear feet $\frac{1}{4}$ -inch rope.

90 square feet $\frac{1}{4}$ -inch mesh wire cloth (vents

and foundation screens).

12 adjusting rods and fittings for windows, as

detailed.

2 sheet-iron pads and heat shields, as detailed.

Latches for doors, shutters, and foundation win-

dows, as desired.

Nails.

10 pounds 20-penny, 180 pounds 10-penny, 400

pounds 8-penny, 50 pounds 6-penny, 15

pounds 8-penny finishing.

Paint.

Three outside coats, 10 gallons.

MATERIALS REQUIRED FOR A SWEET-POTATO STORAGE HOUSE 39 FEET 10 INCHES BY 100 FEET 10 INCHES, HAVING A CAPACITY OF ABOUT 12,000 BUSHELS IN CRATES OR 15,000 BUSHELS IN BULK

This building is designed for the storage of potatoes in crates or in one tier of bins in which the potatoes may be loaded 6 feet high.

Quantities are for dimensions shown on the drawings (8-foot studs) and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

If the potatoes are to be stored in bulk, the items marked with a star (*) are to be omitted. If storage is to be in crates, the stud walls should be 11 feet 4 inches high (instead of 7 feet 10 inches, as shown in the drawings), the items marked with a dagger (†) are to be omitted, and those marked with a star (*) are to be included.

Concrete.*Mixture—*

One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel.

Quantities—

Constituents	Walls	Piers
Cement.....	185 sacks.....	34 sacks.....
Sand.....	21 cu. yds.....	4 cu. yds.....
Gravel.....	34.5 cu. yds.....	6.5 cu. yds.....
Or—		
Cement.....	185 sacks.....	34 sacks.....
Bank-run gravel.....	44 cu. yds.....	8 cu. yds.....

Chimneys.*Mixture for mortar—*

One part Portland cement, three parts sand.

Quantities—

Cement 30 sacks, *4 sacks; sand $3\frac{1}{2}$ cubic yards, *0.3 cubic yard; bricks 5,000, *bricks 600; 6 terra-cotta thimbles, 6-inch; 96 linear feet 8 by 8 inch terra-cotta flue lining, *22 linear feet.

Lumber.*Girders—*

Six 10 by 12 inches by 10 feet.
Fourteen 10 by 12 inches by 16 feet.
One 10 by 12 inches by 14 feet.

Sills—

Thirty-five 2 by 8 inches by 16 feet.

Studs—

†Sixty-two 2 by 6 inches by 18 feet (side).
*One hundred and twenty-four 2 by 6 inches by 12 feet (side).
Nine 2 by 6 inches by 12 feet (over windows).
†Twenty-two 2 by 6 inches by 18 feet (end).
*Twenty 2 by 6 inches by 10 feet (end).
*Forty-four 2 by 6 inches by 12 feet (end).
*Eight 2 by 4 inches by 10 feet.
Two 2 by 6 inches by 14 feet (over doors).

Plates—

Fifty-two 2 by 6 inches by 12 feet (side).
Sixteen 2 by 6 inches by 10 feet (end).

Purlin posts—

†Thirty-six 2 by 4 inches by 16 feet.
†Twenty-four 2 by 4 inches by 14 feet.
*Forty-two 2 by 6 inches by 12 feet.
*Six 2 by 6 inches by 16 feet.

Ties—

Twenty-four 2 by 6 inches by 10 feet.
Twenty-four 2 by 6 inches by 12 feet.
Six 2 by 6 inches by 18 feet (upper).
Twelve 1 by 6 inches by 10 feet (hangers).

Purlins—

Twelve 2 by 6 inches by 12 feet.
†Twelve 2 by 6 inches by 12 feet.
†Six 2 by 6 inches by 10 feet.
Six 2 by 6 inches by 10 feet.
*Six 2 by 8 inches by 10 feet.
*Twelve 2 by 8 inches by 12 feet.

Purlin braces—

Twelve 2 by 6 inches by 14 feet.
*Six 2 by 6 inches by 14 feet.

Rafters—

One hundred and thirty 2 by 6 inches by 12 feet.
One hundred and thirty 2 by 6 inches by 14 feet.
Twelve 1 by 6 inches by 10 feet (ridge).

Collar beams—

Sixteen 2 by 4 inches by 14 feet.
Four 2 by 6 inches by 12 feet.

Joists—

Two hundred and two 2 by 10 inches by 12 feet.
One hundred and one 2 by 10 inches by 18 feet.
800 linear feet 1 by 3 inches (bridging).

Sheathing (includes 20 per cent waste)—

11,870 feet board measure 1 by 6 inches (roof).
5,290 feet board measure 1 by 6 inches (ceiling).
2,920 feet board measure 1 by 6 inches (inside walls).
3,450 feet board measure 1 by 6 inches (outside walls).

Lumber—Continued.*Sheathing—Continued.*

4,800 feet board measure 1 by 6 inches (subfloor).

*2,340 feet board measure 1 by 6 inches.

Drop siding (includes 20 per cent waste)—

3,400 feet board measure 1 by 6 inches.

*1,180 feet board measure 1 by 6 inches.

Flooring (tongue and groove, includes 25 per cent waste)—

5,500 feet board measure 1 by 4 inches (ceiling).

3,440 feet board measure 1 by 4 inches (walls).

5,000 feet board measure 1 by 4 inches (floor).

*1,200 feet board measure 1 by 4 inches.

Trim (surfaced 4 sides)—

Six $1\frac{1}{2}$ by $4\frac{1}{2}$ inches by 14 feet (doors).

†Five $1\frac{1}{2}$ by $4\frac{1}{2}$ inches by 18 feet (corners).

*Eight $1\frac{1}{2}$ by $4\frac{1}{2}$ inches by 12 feet.

Eight $1\frac{1}{2}$ by $4\frac{1}{2}$ inches by 12 feet (end fascia).

Twelve $1\frac{1}{2}$ by $4\frac{1}{2}$ inches by 10 feet (windows).

Twenty-four 1 by 8 inches by 12 feet (baseboards).

Eighteen 1 by 6 inches by 12 feet (roof ridge).

350 linear feet $1\frac{1}{2}$ by $2\frac{1}{2}$ inches (drip molding)

Ventilators in roof (surfaced 4 sides)—

Twelve 1 by 10 inches by 16 feet.

Twelve 1 by 12 inches by 10 feet.

680 linear feet, 1 by 3 inches.

100 linear feet, 1 by 4 inches.

Six 1 by 10 inches by 12 feet (roof boards).

Six 1 by 8 inches by 12 feet (roof boards).

Dividing partitions—

Eight 2 by 4 inches by 10 feet (plates).

*Eight 2 by 4 inches by 10 feet.

Eight 2 by 4 inches by 18 feet (studs).

Eight 2 by 4 inches by 16 feet (studs).

*Four 2 by 4 inches by 16 feet.

Eight 2 by 4 inches by 14 feet (studs).

†Four 2 by 4 inches by 14 feet (studs).

Eight 2 by 4 inches by 12 feet (studs).

Eight 2 by 4 inches by 10 feet (studs).

†Two 2 by 4 inches by 12 feet (over doors).

*Two 2 by 4 inches by 14 feet (over doors).

2,655 feet board measure 1 by 4 inch tongue-and-groove flooring (includes 25 per cent waste).

*690 feet board measure 1 by 4 inch tongue-and-groove flooring (includes 25 per cent waste).

Screens (foundation windows)—

Nine $\frac{3}{4}$ by 2 inches by 16 feet (surfaced 4 sides).

Bins—

†Seventy-two 2 by 4 inches by 18 feet (studs).

†Twenty-one 2 by 2 inches by 18 (nailing strips).

†Twenty-one 1 by 6 inches by 18 feet.¹

†Forty-two 1 by 6 inches by 12 feet.¹

†Twenty-one 1 by 6 inches by 16 feet.¹

†Forty-two 1 by 6 inches by 10 feet.¹

†One hundred and eighteen 1 by 2 inches by 18 feet (cleats for loose boards).

†Forty-two 2 by 6 inches by 12 feet (over bins).

†Twenty-one 2 by 6 inches by 10 feet (over bins).

Seventy-seven 2 by 4 inches by 12 feet (removable floors).

†One thousand nine hundred and thirty-eight 1 by 4 inches by 10 feet (bin sides).

†One hundred and fourteen 1 by 4 inches by 12 feet (bin sides).

Four hundred and sixty-two 1 by 4 inches by 10 feet (removable floors).

Sixty-six 1 by 4 inches by 12 feet (removable floors).

†One thousand and eighty-three 1 by 4 inches by 10 feet (loose slats).

Battens (shutters and doors)—

Twenty-two 1 by 6 inches by 10 feet.

Platforms—

Eight 2 by 4 inches by 10 feet (nailing strips).

Three 2 by 12 inches by 14 feet (carriages).

Four 4 by 4 inches by 12 feet (posts).

One 2 by 8 inches by 14 feet (sides and flooring).

Twenty-eight 2 by 8 inches by 10 feet (sides and flooring).

Ten 2 by 4 inches by 14 feet (joists).

Three 2 by 10 inches by 14 feet (treads).

Roof covering.

As desired, for 4,950 square feet.

Building paper.

230 squares; *22 squares.

¹ Ties at partitions. Stagger joints, using 12's with 18's and 16's with 10's.

Miscellaneous.

- 18 cellar sash and frames for 3 lights, 8 by 10 inch glass.
- 18 single sash and frames for 6 lights, 9 by 12 inch glass (6-inch studs).
- 4 No. 2 glazed doors, 3 by 7 feet, and frames for 6-inch studs.
- 4 frames for inside doors, 3 by 7 feet, 4-inch studs.
- 60 pairs $2\frac{1}{2}$ by $2\frac{1}{2}$ inch galvanized hinges (stove-floor vents and windows).
- 8 pairs 6-inch galvanized T hinges (battened doors).
- 36 pairs 4-inch galvanized T hinges (shutters).
- 12 pairs $\frac{3}{4}$ by $2\frac{1}{4}$ inch sash centers.
- 4 pairs $3\frac{1}{2}$ by $3\frac{1}{2}$ inch loose-pin butts (glazed doors).
- 12 screw eyes (ventilator).
- 144 linear feet $\frac{1}{4}$ -inch rope.
- 24 bolts $\frac{3}{8}$ by 3 inches with 4-inch rings (floor ventilators).
- 130 square feet $\frac{1}{4}$ -inch mesh galvanized wire cloth (vents and foundation screens).

Miscellaneous—Continued.

- 50 bolts, nuts, and washers, $\frac{5}{8}$ by 18 inches foundation).
- 40 linear feet galvanized flashing 12 inches wide (around chimneys).
- 100 linear feet galvanized flashing 8 inches wide (roof ventilators).
- 8 wrought-steel straps $\frac{1}{4}$ by $2\frac{1}{2}$ by 18 inches (platform posts).
- 16 lag screws $\frac{1}{4}$ by 3 inches (platform posts).
- 18 adjusting rods and fittings for windows, as detailed.
- 6 sheet-iron pads and heat screens, as detailed.
- Latches for doors, shutters, and foundation windows, as desired.
- Nails.**
- 12 pounds 30-penny, 25 pounds 20-penny, 77 pounds, 10-penny, 930 pounds 8-penny, 190 pounds 6-penny, 30 pounds 8-penny finishing.
- Paint.**
- Three outside coats, 20 gallons.

UTILIZING ABANDONED TENANT HOUSES, WAREHOUSES, AND OTHER STRUCTURES FOR STORING SWEET POTATOES

On many farms in the South there are abandoned tenant houses and various other buildings that can be converted into sweet-potato storage houses at very little expense. In many towns there are warehouses, store buildings, and other structures that can be utilized to advantage for storing sweet potatoes. Where such structures are available on the farms or in towns they should be utilized before erecting new houses. The same methods of insulating and ventilating should be used in remodeling old structures as are recommended for new sweet-potato storage houses. Where the interior of the house to be remodeled is not already sheathed it is advisable to nail a layer of 1 by 4 or 1 by 6 inch boards on the studding, then a layer of building paper, and over this matched boards, as shown in Figure 11. The tighter the house is made, the less attention is required to keep the temperature and moisture under proper control.

Where only a few bushels of sweet potatoes are to be stored they may be kept in a loft over the kitchen or in any place in the house where the temperature is quite uniform (between 50° and 60° F.) and the air rather dry.

VARIETIES OF SWEET POTATOES FOR MARKET

The varieties of sweet potatoes to grow depend upon the market to be supplied. The northern and eastern markets prefer a dry, mealy potato, such as the Big-Stem Jersey, Yellow Jersey, and Gold Skin, although such varieties as the Nancy Hall, Dooley, and Triumph have been sold to good advantage in all the northern markets. The main reason that southern-grown sweet potatoes have not been in greater demand on the northern markets is because they have been poorly graded and packed. The markets of the South prefer the moist varieties, such as Porto Rico, Nancy Hall, Dooley, and Pumpkin "yam." The Triumph, a light-colored, moderately dry fleshed sweet potato, is grown to some extent for shipping to northern markets early in the season.

The southern farmers should supply their own markets, before trying to ship potatoes to northern markets. During late winter and early spring many large towns and cities of the South are poorly supplied, because of lack of storage facilities. With storage houses, these markets could be supplied with southern-grown potatoes throughout the season. The markets of the West will take the moister fleshed potatoes grown in the South, and a good trade could be built up in this region if the growers would use greater care in grading and packing.

While the varieties of sweet potatoes now grown in the South are preferred by the southern people, the dry, mealy roots sell best in the markets of the North. The grower should aim to give the consumers what they want, and for northern markets the dry or semimoist varieties should be grown, regardless of the grower's preference.

HARVESTING SWEET POTATOES

Careful handling is one of the essentials in keeping sweet potatoes, and there is no more important place to practice it than in the field at digging time. The implement used to dig sweet potatoes should be one that does not cut or bruise the roots. One of the best types of diggers is a plow with rolling colters on the beam to cut the vines and with rods attached to the moldboard to free the roots from the soil and vines (fig. 12). A "middle buster" is also a good implement for digging sweet potatoes. After the potatoes are dug they should be scratched out by hand and allowed to remain exposed long enough to dry. They should never be thrown from one row to another, thrown loose into the wagon bed, or put into bags. The digging should be done, if possible, when the weather is bright and the soil dry.

Sweet potatoes should be graded in the field, in order to reduce the cost of handling to a minimum. A good plan is to go over the rows and pick up the sound, marketable potatoes in one basket, then gather all the seed stock in another basket or box and put the injured ones in still another. These boxes or baskets should be loaded on a wagon

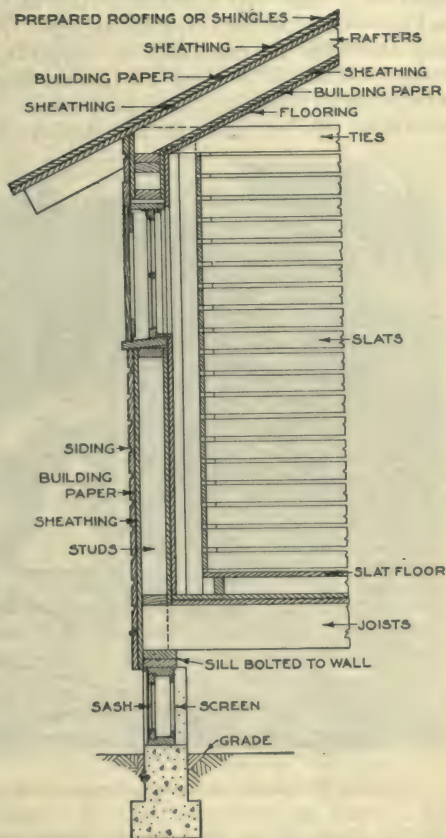


FIG. 11.—Details of the foundation, floor, wall, and roof construction of a sweet-potato storage house

with springs and hauled direct to the storage house. If the potatoes are to be stored in baskets, boxes, or crates, the different grades should be put by themselves, and when stored in bulk they should be placed in separate bins. By following this method it will not be necessary to grade the potatoes at the storage house when putting them in. This will effect a saving of time, reduce the loss by decay, and save the cost of extra handling. The potatoes should be emptied into the bins as carefully as possible, to prevent bruising. Sweet potatoes can be stored in boxes, hampers, baskets, or bins with satisfactory results. The preference of the individual grower will determine the method to be employed.



FIG. 12.—A type of digger with rolling colters attached to the beam, often used for digging sweet potatoes

Each year, after the sweet potatoes have been marketed, the storage house should be thoroughly cleaned and disinfected before it is used again. All dirt and refuse should be cleaned out and all parts of the interior sprayed or washed thoroughly with a solution of formalin (1 pint of formalin to 10 or 15 gallons of water). Diseased roots should not be thrown on the manure pile or on land to be used for sweet potatoes; the safest plan is to burn them.

CRATE STORAGE

Where crates are used, a slat floor raised 4 inches from the main floor should be provided, in order to allow air circulation under the crates, and they should be stacked in even rows to the height of 8 feet. A satisfactory method is to stack each row of crates on two 2 by 4 inch pieces set on edge, parallel to each other, and about 1 foot apart, thus permitting ventilation under the crates and acting as a substitute for the slat floor. This is important in order to protect the potatoes in the first row of crates.

FILLING THE BINS

In filling the storage house, the workmen should begin at the back end of the bins and pour a layer of sweet potatoes about 2 feet deep in all of the bins rather than fill one bin at a time. If the bins are 8 or 10 feet long, it is a good plan to divide them into two parts. By nailing cleats to the middle support of the bins, as shown in Figures 4 and 6, the partition can be raised as the bins are filled. The partition boards should have some space between them to allow free circulation of air. A 1-inch block between the boards will be satisfactory to separate them. By dividing the bins in this way, the back of the bin can be filled without climbing over the potatoes in the front part. When taking the potatoes out, those in one section of a bin can be removed without disturbing the remainder. This is very important where they are sold in small quantities.

CURING SWEET POTATOES

While the newly dug sweet potatoes are being brought in, a fire should be kept in the storage house to dry off the moisture. A temperature of 80° to 85° F., with plenty of ventilation, should be maintained for 10 days or two weeks, depending on weather conditions and the variety of potatoes. Ventilation is absolutely necessary, and even if it is not possible to keep the temperature up to 80° F., it is necessary to leave the doors, windows, and ventilators open, so as to drive out the moisture-laden air. The doors and windows may be closed at night and should be kept closed on cloudy days. Some of the ventilators in the floor and through the ceiling should be kept open throughout the curing period, even in cloudy or rainy weather. The air inside the house should be kept warmer than the outside air during the curing period. This will prevent moisture from being deposited on the walls. As the air warms, it expands and takes up moisture. When it cools it contracts and gives up its moisture. This makes it important to get the moisture-laden air out of the house by ventilation. When the potatoes are thoroughly dried or cured, the temperature should be gradually reduced to 55° F. and kept as near that point as possible during the remainder of the storage period. If the temperature goes below 48° F., a fire should be made and the temperature raised to 55° F. When the temperature goes above 60° F., the house should be opened in the cool of the day to lower the temperature to 54° or 55° F., and then closed. In mild weather the ventilators in the roof may be partly open all the time, but they should be closed in cloudy or cold weather.

METHODS OF HEATING A STORAGE HOUSE

A small house can be heated with a sheet-iron stove that will burn knots and other pieces of wood. Coal stoves may be used if preferred, but air-tight wood stoves will serve the purpose. It requires a longer time to get up heat with a coal stove than with a wood stove, and this is one disadvantage in using coal. Often all that is necessary to raise the temperature a few degrees is to start a little wood fire. In a commercial storage house a hot-air heater or a hot-water boiler, with pipes around the walls, would be prefer-

able to a stove, but a house that will hold as many as 10,000 to 25,000 bushels of sweet potatoes may be heated with good stoves. The location of the stoves in the house depends on the size of the house and the direction of the cold winds. Ordinarily, where one stove is used, it is placed near the center of the house, but if the cold wind strikes one end the stove should be in that end. The larger houses have a stove in each end, but in cases where the house is divided into rooms it is necessary that a stove be placed in each room. Considerable open space should be left around the stoves to prevent the potatoes from being injured by excessive heat. In large houses it is desirable to put in partitions to make separate rooms. Each room should have a stove or other independent heating unit. Small storage houses are sometimes heated with oil stoves with satisfactory results. In most sections of the South it is not necessary to keep heat in the storage house much of the time. It is only necessary to build a



FIG. 13.—A pile of sweet potatoes ready to be covered with cane tops and soil. Note the ventilating hole which extends through the center of the pile

fire when the temperature in the house goes below 48° F. or during wet weather, when moisture is likely to deposit on the walls. When the outside temperature goes to 60° F. or above during the day, the house may be opened for a few hours, provided the atmosphere is fairly dry, in order to raise the temperature inside to the desired point. When the temperature reaches 55° F. the house should be closed. By giving close attention to opening and closing the house, very little artificial heat will be needed in the lower South after the curing period.

STORAGE PITS AND CELLARS

Storage in banks and pits is sometimes necessary, and the best methods of storing in them and in outdoor cellars are here described. The main disadvantages in the pit or bank method of storage are (1) the large proportion of loss due to decay; (2) the inferior quality of the sound potatoes, due to lack of proper curing; (3) the loss on the market, because banked potatoes will keep for such a short period after being removed; and (4) the inconvenience of getting

the potatoes when needed, especially during cold or rainy weather. If it is impossible to build a storage house the potatoes should be cared for in some other way, and it is much better to store in pits or outdoor cellars than not to store them at all. By using the best

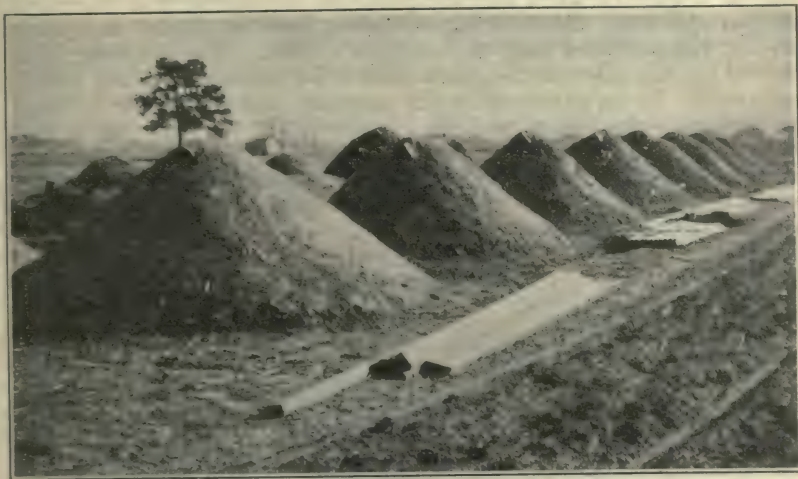


FIG. 14.—A number of sweet-potato banks, illustrating the method of ventilation by the use of troughs at the top of each pile

methods of banking known, the loss by decay can be materially reduced but not eliminated, because it is impossible to control the moisture and temperature.



FIG. 15.—A type of outdoor cellar used in some sections of the South for storing sweet potatoes. This structure should have openings near the bottom and through the top for the purpose of ventilation

Storage pits should be located where the drainage is good. In making a pit a little of the surface soil is thrown back to form a level bed of the size desired. It is a good plan to dig two small trenches across the bed at right angles to each other to provide for ventilation

at the bottom. Lay boards or place troughs over the trenches, and at the point where the trenches cross set a small box on end to form a flue up through the pile of potatoes, as shown in Figure 13. The earth floor of the pit is covered with 4 or 5 inches of straw, hay, leaves, or pine needles, and the potatoes are placed in a conical pile around the flue. A covering of straw, hay, or similar material is put on the pile and over this a layer of soil. The covering of soil should be only a few inches thick at first but increased as the weather gets cold. Keep the ends of the trenches and flue open until it is necessary to close them to keep out the frost. It is better to make several small pits rather than one large one, because it is best to remove the entire contents when the pit is opened. Figure 14 shows a number of pits with a trough ventilator placed over the top of each pile of potatoes.

A type of storage cellar similar to the one shown in Figure 15 is often used in the South for storing sweet potatoes. This form of



FIG. 16.—Hampers of sweet potatoes separated into two grades. This type of package is used at considerable extent by growers in New Jersey

storage is much better than pits or banks. The potatoes can be cured in the outdoor cellar, and it is easier to get them out when wanted for the table or for market. A good type of outdoor cellar can be made as follows: Set a line of posts for the center supports and on these posts put a ridgepole. Against the ridgepole place one end of planks, poles, or slabs, with their opposite ends resting on the ground on either side. The ends of the inclosure are boarded up, a door being provided in one end. The structure is covered with sod to a thickness of 5 or 6 inches. It is a good plan to put a ventilator through the top and to leave two or three openings in the sides near the ground. Provision should be made to close all these openings during cold or wet weather. By placing a small stove in the storage cellar the potatoes can be cured in the way that has been described for the storage house. The potatoes are usually piled on a layer of straw, leaves, or pine needles placed on the ground. A better method is to build a slat floor a few inches from the ground and pile the potatoes on the floor. This floor will allow the circulation of air under the potatoes, which will aid in curing them.

MARKETING SWEET POTATOES

One reason why southern farmers have not received better prices for sweet potatoes is that they have not used proper methods of handling and marketing. In many cases the potatoes are badly bruised and cut in digging, put in bags or rough barrels without grading, and rushed to market when there is an oversupply. The secrets of success in getting high prices are to carefully grade, clean, and pack the product and to put it upon the market when there is a good demand. The greatest demand for sweet potatoes is, as a rule, from the middle of December to the middle of March.

When the potatoes are to be marketed they must be carefully graded, no matter how well the grading had been done when they were put in the house. The market demands a medium-sized uniform type of sweet potato, free from bruises or decayed spots. In grading, the large, overgrown, crooked, broken, or bruised roots should be kept at home for feeding or for canning. The best potatoes will bring a higher price when separated from the culls.

After careful grading, the sweet potatoes should be put in clean, neat, attractive packages. Bags should never be used, as the potatoes in them become badly bruised when handled. The standard veneer potato barrel with a burlap cover is often used in summer or autumn, but for winter shipment the double-headed stave barrel or tight box is used. The smaller type of package, such as the bushel hamper (fig. 16), bushel box, or basket, is becoming more popular each year. A neat and attractive package of well-graded potatoes will bring a good price at almost any time, even when the market is overstocked with inferior goods.

Sweet potatoes when shipped during the winter must be protected from the cold. When a potato becomes chilled its quality is impaired, and decay soon follows. In cold weather the package should be covered with paper and the cars heated, in order to prevent chilling the potatoes. Some shippers find it an advantage to line their baskets and barrels with paper. For more complete information on packing, shipping, and marketing sweet potatoes, see United States Department of Agriculture Bulletin 1206, "Marketing Southern-Grown Sweet Potatoes."

PUBLICATIONS ON SWEET POTATOES

- Sweet-Potato Growing (Farmers' Bulletin 999).
- The Sweet-Potato Weevil and Its Control (Farmers' Bulletin 1020).
- Sweet-Potato Diseases (Farmers' Bulletin 1059).
- Utilization of Flue-Heated Tobacco Barns for Sweet-Potato Storage (Farmers' Bulletin 1267).
- United States Grades for Sweet Potatoes. Recommended by the United States Department of Agriculture (Department Circular 99).
- Eradication of the Sweet-Potato Weevil in Florida (Department Circular 201).
- Group Classification and Varietal Descriptions of American Varieties of Sweet Potatoes (Department Bulletin 1021).
- A Study of Sweet-Potato Varieties, with Special Reference to Their Canning Quality (Department Bulletin 1041).
- Sweet-Potato Storage Studies (Department Bulletin 1063).
- Production of Sirup from Sweet Potatoes (Department Bulletin 1158).
- Marketing Southern-Grown Sweet Potatoes (Department Bulletin 1206).

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1443

DAIRY CATTLE BREEDS



U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF ANIMAL INDUSTRY
WASHINGTON, D. C.

SEVERAL BREEDS of cattle in the United States are recognized as dairy breeds. Although much alike in what is known as general dairy conformation, these breeds differ to some extent in certain characteristics. What these characteristics are, the factors to consider in selecting a breed, and the history of the origin and development of the breeds are questions of interest to both the beginner and the established breeder of dairy cattle. These are the topics discussed in this bulletin.

This bulletin supersedes Farmers' Bulletin 893, Breeds of Dairy Cattle.

Washington, D. C.

Issued February, 1925; revised September, 1926

DAIRY CATTLE BREEDS

By AMER B. NYSTROM, *Dairy Husbandman, Bureau of Dairy Industry*

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DAIRY CATTLE IN THE UNITED STATES

ACCORDING to estimates made by the United States Department of Agriculture there were about 33,000,000 dairy cattle of all ages in the United States on January 1, 1926. Three per cent of these cattle, or about 1,000,000, are purebred, and represent six breeds, namely, Ayrshire, Brown Swiss, Dutch Belted, Guernsey, Holstein-Friesian, and Jersey. The improvement that must be made in the 97 per cent that are not purebred must come largely from the 3 per cent that are purebred. Likewise, any increase in the number of our purebred dairy cows, and even the maintenance of our grade dairy herds at their present number and efficiency, will be accomplished principally through the use of purebred bulls. For these reasons purebred dairy cattle have played in the past and will play in the future a very important rôle in the dairy industry of the Nation.

NUMBER AND DISTRIBUTION OF BREEDS

Tables 1 and 2 show the number and distribution of the various breeds in the United States, by sections and by States. The information in Table 1, showing total number of each breed on January 1, 1920, was brought out by an inquiry sent to 14,000 special livestock reporters of the branch then known as the Bureau of Markets and Crop Estimates of the United States Department of Agriculture. Grades and scrubs were listed with the respective breeds to which they seemed to belong.

Table 2 shows the number of registered purebreds of the dairy breeds on January 1, 1920, as ascertained by the census.

Table 3 gives the average annual production of milk and butterfat of the cows having official yearly records in the breed associations.

TABLE 1.—Estimated number and percentage of cattle of dairy breeds, including purebreds and grades, in the United States, January 1, 1920, by sections

Breed	Total	United States	North Atlantic States	North Central, East	North Central, West	South Atlantic States	South Central States	Far West
	<i>Number</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Ayrshire.....	412,000	1.8	5.8	0.8	1.9	0.7		0.8
Brown Swiss.....	170,000	.7	.5	1.3	1.3	.3		.4
Dutch Belted.....	157,000	.7	.5	.2	.6	.3	2.3	
Guernsey.....	1,903,000	8.5	10.6	12.1	11.9	8.4	1.3	5.1
Holstein-Friesian.....	11,009,000	47.4	65.3	56.2	54.3	21.1	17.3	58.9
Jersey.....	9,554,000	40.9	17.3	29.4	30.0	69.2	79.1	34.8
Total.....	23,355,000	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 2.—Purebred (registered) cattle of the dairy breeds on farms in 1920, by States and sections, as shown by the census

Division and State	Total	Ayrshire	Brown Swiss	Guernsey	Holstein-Friesian	Jersey	All other breeds ¹
United States.....	916,602	30,509	8,283	79,446	528,621	231,834	37,909
Geographic divisions:							
New England.....	85,724	9,780	349	10,311	42,721	20,305	2,258
Middle Atlantic.....	289,704	12,883	1,904	21,114	171,124	25,815	6,924
East North Central.....	289,859	3,735	4,199	29,640	185,475	57,167	9,643
West North Central.....	106,967	1,859	1,386	8,250	62,055	23,697	9,720
South Atlantic.....	49,119	519	43	5,949	15,445	25,245	1,918
East South Central.....	34,651	27	3	298	5,902	27,024	1,397
West South Central.....	43,268	60	13	263	9,724	30,650	2,558
Mountain.....	22,534	324	146	838	12,689	6,926	1,611
Pacific.....	44,716	1,322	240	2,783	23,486	15,005	1,880
New England:							
Maine.....	15,683	1,134	62	1,836	7,206	4,999	446
New Hampshire.....	10,750	1,214	75	1,151	6,695	1,348	267
Vermont.....	28,549	3,808	59	2,193	13,413	8,446	630
Massachusetts.....	18,807	1,880	80	3,348	10,006	2,904	589
Rhode Island.....	1,651	494	—	217	542	351	47
Connecticut.....	10,284	1,250	73	1,566	4,859	2,257	279
Middle Atlantic:							
New York.....	153,037	9,521	1,347	9,749	114,662	13,411	4,347
New Jersey.....	11,568	265	23	1,747	7,810	1,308	325
Pennsylvania.....	75,189	3,097	534	9,618	48,652	11,036	2,252
East North Central:							
Ohio.....	70,882	1,021	324	4,960	38,327	23,842	2,408
Indiana.....	21,115	509	131	1,215	8,477	9,921	862
Illinois.....	36,412	202	1,385	1,369	25,124	7,317	1,015
Michigan.....	46,533	291	429	3,369	32,702	8,296	1,446
Wisconsin.....	114,917	1,712	1,930	18,727	80,845	7,791	3,912
West North Central:							
Minnesota.....	32,668	399	483	4,468	22,830	2,508	1,980
Iowa.....	20,286	271	447	1,716	10,916	3,629	3,307
Missouri.....	19,037	110	135	760	5,569	10,708	1,755
North Dakota.....	4,797	226	23	346	2,937	481	784
South Dakota.....	5,248	85	119	135	4,027	312	570
Nebraska.....	7,873	74	38	348	5,368	1,275	770
Kansas.....	17,058	694	141	477	10,408	4,784	554
South Atlantic:							
Delaware.....	1,691	1	—	246	1,245	172	27
Maryland.....	8,668	113	9	1,867	4,073	2,323	283
District of Columbia.....	186	—	—	1	175	10	—
Virginia.....	9,586	25	—	1,696	4,160	3,223	482
West Virginia.....	4,450	272	32	333	1,134	2,546	133
North Carolina.....	7,697	44	1	789	1,613	4,978	272
South Carolina.....	5,184	4	—	644	1,008	3,389	139
Georgia.....	8,727	14	1	305	1,700	6,224	483
Florida.....	2,930	46	—	68	337	2,380	99
East South Central:							
Kentucky.....	8,829	20	—	40	2,046	6,421	302
Tennessee.....	11,347	2	1	111	1,383	9,424	426
Alabama.....	6,108	4	2	46	1,142	4,608	306
Mississippi.....	8,367	1	—	101	1,331	6,571	363
West South Central:							
Arkansas.....	6,950	3	1	19	2,001	4,627	220
Louisiana.....	3,415	1	2	94	1,009	2,201	108
Oklahoma.....	9,539	37	3	91	3,741	5,104	563
Texas.....	23,364	19	7	59	2,973	18,718	1,588
Mountain:							
Montana.....	3,451	13	54	176	2,453	560	195
Idaho.....	4,138	46	43	197	2,049	1,579	219
Wyoming.....	1,071	21	14	31	747	167	91
Colorado.....	6,448	114	30	241	4,057	1,605	401
New Mexico.....	1,327	—	—	42	438	507	340
Arizona.....	2,772	109	—	48	1,778	669	168
Utah.....	2,922	—	—	93	970	1,706	153
Nevada.....	405	21	—	10	197	133	44
Pacific:							
Washington.....	12,720	404	69	941	7,673	3,402	231
Oregon.....	12,852	323	135	697	3,624	7,771	302
California.....	19,144	595	36	1,145	12,189	3,832	1,347

¹ Including animals reported as purebred, but with breed not specified.

TABLE 3.—Average yearly production of milk and butterfat of the cows of different breeds that have official yearly records

Breed	Number of cows and heifers	To what date	Milk	Butterfat	
				Quantity	Test
			<i>Pounds</i>	<i>Pounds</i>	<i>Per cent</i>
Ayrshire.....	6,368	Jan. 1, 1925	10,256	407.48	3.97
Brown Swiss.....	476	Jan. 1, 1926	12,534	501.60	4.00
Dutch Belted.....	46	Jan. 1, 1926	10,141	384.64	3.80
Guernsey.....	20,931	Jan. 1, 1926	9,615	480.10	4.99
Holstein-Friesian.....	23,622	Jan. 1, 1926	15,697	532.44	3.39
Jersey.....	22,355	Jan. 1, 1925	8,287	444.37	5.36

WHAT IS A DAIRY BREED?

The term "dairy breed" has been accepted by stockmen and investigators as referring to the breeds of cattle that are especially well fitted for the production of milk and butterfat. Such breeds represent the efforts made by breeders of many generations toward improving the milking capacity of certain classes of cows. Because of this fact the inherent tendency of purebred dairy cattle to produce milk is greater than that of a native or unimproved cow. This inherent capacity is transmitted to the offspring. As a result, the mating of a purebred dairy animal with a native or scrub produces a grade animal which is superior to the scrub in production and in other dairy characteristics.

A purebred dairy animal is one that meets the requirements for registration laid down by the association for that breed in the United States. A grade is the offspring resulting from mating a purebred with a scrub, or from mating animals not purebred but having close purebred ancestors. The offspring of a purebred and a grade is also a grade, and through progressive improvement such animals become high grade. The names of the breeds (Ayrshire, Brown Swiss, etc.) may refer to either purebreds or grades; but to prevent misunderstanding it is desirable to precede the breed name with the word "purebred" or "grade."

In addition to the breeds of dairy cattle mentioned, certain other breeds having good milking qualities are kept for dairy purposes. Such cattle, which are often referred to as dual-purpose animals because of their ability to produce satisfactory carcasses as well as a good milk flow, include the Shorthorn, Red Polled, and Devon. The qualities of these are discussed in Farmers' Bulletin 612, "Breeds of Beef Cattle."

REGISTRATION

A purebred dairy animal is one whose sire and dam are eligible to be recorded by name and number in a register of the breed, commonly called the herdbook. An animal thus qualified may itself be recorded in the same herd register, provided the sire and dam are registered, and provided it also qualifies with regard to color. Additional rules and requirements for registration are laid down by the various breed organizations. Copies of these rules may be obtained by writing to the association concerned, as listed on page 30 of this bulletin.

In addition to the herd register, there is for each breed another register in which are entered the names of purebred cows that have completed records meeting specified requirements of milk and butter-fat production under definite regulations. Bulls that have a certain number of tested daughters are also recorded in this register. This record of tested cows and proved bulls is called by various names—Advanced Registry for the Ayrshires and Dutch Belted, Register of Production for the Brown Swiss, Advanced Register for the Guernseys and Holsteins, and Register of Merit for the Jerseys.

The requirements for admission to this special register of production and the rules under which the records are made vary somewhat with different breeds. Detailed information on this point may be obtained from the breed associations concerned.

WHICH BREED TO SELECT

Sometimes too much emphasis is given to the question which breed to choose, and too little to the matter of getting good individuals—that is, those that are well bred and high producers. There are three points, however, that should be considered in deciding which breed to select. These are: (1) The breed that predominates in the locality where the new herd is to be located, (2) personal preference, and (3) market requirements for the product.

THE BREED THAT PREDOMINATES

A dairyman just starting with purebreds may feel that since all his neighbors have one breed of cattle, he should get another breed so as to have a monopoly in the business of selling breeding stock. There is no question about the monopoly, but there would probably be no business to monopolize. It is difficult for an isolated small breeder to dispose of his surplus stock to advantage, while if there are many breeders with the same breed buyers are attracted to the locality because of the better chance to get the desired animals from one or more of the several breeders.

There are other advantages to a dairyman in having the same breed as his neighbor, such as the possibility of exchanging bulls, and of owning good purebred bulls cooperatively. These advantages are obtained by those having grade herds as well as by those with purebreds. Then there is also the opportunity for taking advantage of special breed sales of surplus stock, and, lastly, the advantage of bringing the community together in other endeavors which usually result where there is but one breed.

PERSONAL PREFERENCE

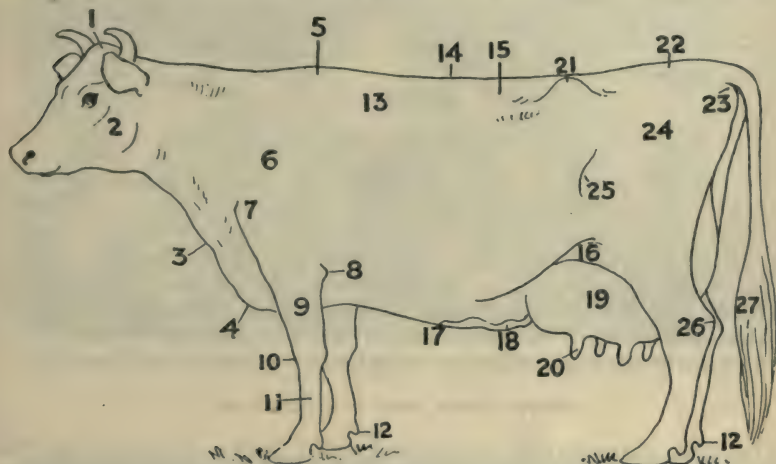
In a district where no breed is established, or in sections where all the different breeds are about equally represented, the prospective breeder must be guided largely by his personal preference. A person usually takes a liking to one breed, for reasons not easily explainable. Naturally he would take more interest in caring for animals of that breed than for those of a breed that he does not like so well.

Personal preference, however, must not overshadow the matter of quality of individual animals. If high-producing individuals of the breed not so well liked are available at reasonable cost, and individuals of the same quality of the breed well liked are not available except at a much higher cost, it may be wiser to select the former, for usually a dairyman soon begins to like a breed with which he is doing well.

MARKET REQUIREMENTS FOR PRODUCT

Market requirements for the product should not be overemphasized in selecting the breed. For a time a dairyman may sell his product in a market where low-testing milk has the advantage, while later the conditions may be changed, and a high-testing milk will sell to better advantage. Obviously, a breeder can not shift from one breed to another to meet the fluctuations in market demands.

When selling to a city milk plant, however, the price paid for the extra fat over the basic test, or deducted from the standard price when



- | | | |
|----------------------|---------------|---------------|
| 1. POLL | 10. KNEE | 19. UDDER |
| 2. JAW | 11. SHANK | 20. TEAT |
| 3. DEWLAP | 12. DEW CLAW | 21. HIP POINT |
| 4. BRISKET | 13. CROP | 22. RUMP |
| 5. WITHERS | 14. CHINE | 23. PIN BONE |
| 6. SHOULDER | 15. LOIN | 24. THURL |
| 7. POINT OF SHOULDER | 16. FLANK | 25. STIFLE |
| 8. POINT OF ELBOW | 17. MILK WELL | 26. HOCK |
| 9. FOREARM | 18. MILK VEIN | 27. SWITCH |

FIG. 1.—Diagram of cow showing names and location of parts

the milk is below basic test, may well be considered in selecting the breed. The point here is that sometimes in some whole-milk markets the differential may favor high-testing milk, and at other times or in other markets it may favor low-testing milk.

In summing up the matter of which breed to select this point should be kept in mind—there are good cows and poor cows in all breeds, and, other things being equal, the breeder or dairyman who gets good individuals to begin with will have a good chance for success, no matter what breed he selects.

THE SCORE CARD

Each breed association has a scale of points, or score card, for bulls and cows of that breed. The card gives definite values for the various characteristics of conformation, and emphasizes points requiring special attention from breeders. The purpose of the score card is to teach beginners the art of judging, and also to encourage the formation of what is considered by breeders, through their associations, as the ideal type. It tends to make the breed uniform in appearance. The scale of points for a cow is given in this bulletin with the description of each breed.

In order to make the score cards more useful a diagram is given in Figure 1, which names and locates the various parts referred to on the score cards.

AYRSHIRE

ORIGIN AND HISTORY

The Ayrshire breed originated in southwestern Scotland, in the county of Ayr, in the latter part of the eighteenth century. Doubtless cattle from several neighboring countries were used in the formation of the breed, though there is no record of direct foreign importations to the county of Ayr at that time. While this foreign blood probably had a good effect on the ultimate value of the breed, the substantial and efficient development of the breed seems to have come about mostly through subsequent judicious selection and mating.

IMPORTATION AND DISTRIBUTION

The first importations into the United States occurred in 1822. Since then Ayrshires have been imported almost every year, either from Scotland or Canada. As indicated by Tables 1 and 2, there are about 30,000 registered Ayrshires in the United States and about 400,000 grades carrying more or less Ayrshire blood. These cattle are found scattered through 46 of the 48 States of the Union, though by far the largest numbers are to be found in the Northeastern States.

GENERAL CHARACTERISTICS

The Ayrshire has a well-built, stocky body, not heavily covered with flesh, but giving the appearance of great vigor and vitality. The calves weigh from 60 to 80 pounds at birth. The weight of mature bulls varies from 1,500 to 2,000 pounds, with an average of about 1,650 pounds, while mature cows range in weight from 850 to 1,250 pounds, and average about 1,050 pounds.

The color varies from almost pure white to nearly all cherry red or brown, with any combination of these colors. Usually the tail is white. The horns are large, and turn gracefully outward, then forward and back, giving a distinctive appearance to the head.

Ayrshire cows are noted for their symmetrical udders, which extend well forward and back, with no tendency to be pendent. The quarters are generally even, the teats medium in size and well placed.

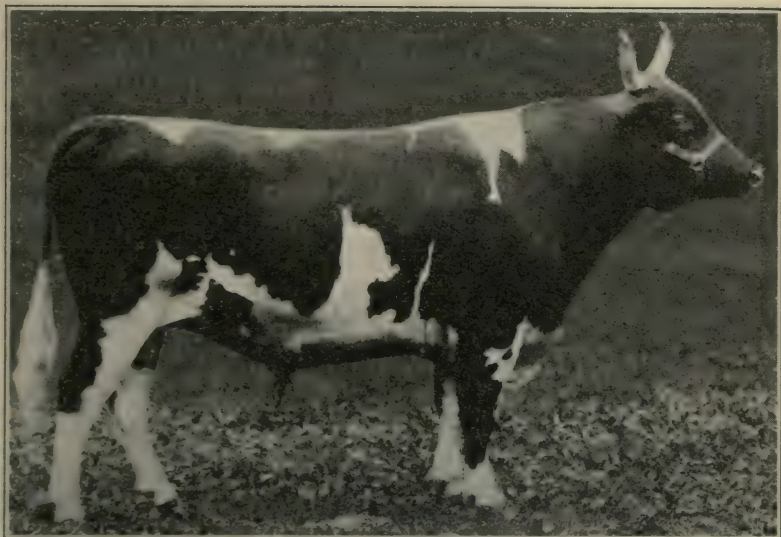


FIG. 2.—Ayrshire bull, Strathglass Roamer 28189. Grand champion, National Dairy Show, 1925



FIG. 3.—Ayrshire bull, Beuchan Peter Pan 12971. Fifty-seven of his daughters are in the Advanced Registry

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FIG. 4.—Ayrshire cow, Lily of Willowmoor 22269. Champion butterfat producer of the breed



FIG. 5.—Ayrshire cow, Garclaugh May Mischief 27944. Champion milk producer of the breed

Dairy Cattle Breeds

9

Scale of points for Ayrshire cow

Head	10
Forehead, broad and clearly defined	1
Horns, wide set on and inclining upward	1
Face, of medium length, slightly dished; clean cut, showing veins	2
Muzzle, broad and strong without coarseness, nostrils large	1
Jaws, wide at the base and strong	1
Eyes, full and bright with placid expression	3
Ears, of medium size and fine, carried alert	1
Neck, fine throughout, throat clean, neatly joined to head and shoulders, of good length, moderately thin, nearly free from loose skin, elegant in bearing	3
Fore quarters	10
Shoulders, light, good distance through from point to point but sharp at withers, smoothly blending into body	2
Chest, low, deep and full between back and forelegs	6
Brisket, light	1
Legs and feet, legs straight and short, well apart, shanks fine and smooth, joints firm, feet of medium size, round, solid and deep	1
Body	13
Back, short and straight, chine lean, sharp and open jointed	4
Loin, broad, strong, and level	2
Ribs, long, broad, wide apart, and well sprung	3
Abdomen, capacious, deep, firmly held up with strong muscular development	3
Flank, thin and arching	1
Hind quarters	11
Rump, wide, level, long from hooks to pin bones, a reasonable pelvic arch allowed	3
Hooks, wide apart and not projecting above back nor unduly overlaid with fat	2
Pin bones, high, wide apart	1
Thighs, thin, long, and wide apart	2
Tail, fine, long, and set on level with back	1
Legs and feet, legs strong, short, straight, when viewed from behind and set well apart; shanks fine and smooth, joints firm, feet medium size, round, solid, and deep	2
Udder, long, wide, deep but not pendulous nor fleshy; firmly attached to the body, extending well up behind and far forward; quarters even; sole nearly level and not indented between teats, udder veins well developed and plainly visible	22
Teats, evenly placed, distance apart from side to side equal to half the breadth of udder, from back to front equal to one-third the length; length $2\frac{1}{2}$ to $3\frac{1}{2}$ inches, thickness in keeping with length, hanging perpendicularly and not tapering	8
Mammary veins, large, long, tortuous, branching, and entering large orifices	5
Escutcheon, distinctly defined, spreading over thighs, and extending well upward	2
Color, red of any shade, brown, or these with white; mahogany and white, or white, each color distinctly defined. (Brindle markings allowed but not desired)	2
Covering	6
Skin, medium thickness, mellow, and elastic	3
Hair, soft and fine	2
Secretions, oily, of rich brown or yellow color	1
Style, active, vigorous, showing strong character, temperament inclined to nervousness but still docile	4
Weight, at maturity not less than 1,000 pounds	4
Total	100

PRODUCTION

Ayrshire milk contains a percentage of butterfat that is about the average of all the dairy breeds. The 6,368 cows and heifers that completed official records up to January 1, 1925, produced an average of 10,256 pounds of milk per cow, containing 407.48 pounds of butterfat, or 3.97 per cent butterfat.

The 10 highest producers of butterfat and milk among the Ayrshires are listed below:

Ten highest Ayrshire yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	<i>Pounds</i>		<i>Pounds</i>
Lily of Willowmoor 22269.....	955.56	Garclaugh May Mischief 27944.....	25,329
Auchenbrain Brown Kate 4th 27943.....	917.60	Mistress Thistle of South Farm 49818.....	23,029
Garclaugh May Mischief 27944.....	894.91	Auchenbrain Brown Kate 4th 27943.....	23,022
Auchenbrain Yellow Kate 3d 36910.....	888.33	Lily of Willowmoor 22269.....	22,596
Agawam Bess Howie 43781.....	876.13	Garclaugh Spottie 27950.....	22,589
Harperland Spicy Lass 40652.....	866.21	Nancy Whitehall 47810.....	22,075
Jean Armour 3d 32219.....	859.65	Jean Armour 3d 32219.....	21,938
Nancy Whitehall 47810.....	858.77	Bloomer's Queen 39119.....	21,820
Bloomer's Queen 39119.....	856.41	Willowmoor May Mischief 2d A 34173.....	21,161
Victor's Beauty Rose 44021.....	840.65	Auchenbrain Yellow Kate 3d 36910.....	21,123

BULLS

The 10 Ayrshire sires having the largest number of daughters with official yearly records, up to January 1, 1926, are listed below.

Ten Ayrshire sires having the largest number of Advanced-Registry daughters

Sire	Number of daughters	Sire	Number of daughters
Beuchan Peter Pan 12971.....	57	Nox'emall 7312.....	35
Finlayston 8882.....	55	White Cloud of Hickory Island 10377.....	32
Baron's Best Bargenoch 12858.....	47	Netherton Statesman 11643.....	31
Earl's Choice of Spring Hill 8289.....	43	Kate's Good Gift 15426.....	30
Kate's Champion of Penhurst 18782.....	38	Morton Mains Queechy 11537.....	27

BROWN SWISS

ORIGIN AND HISTORY

The original home of the Brown Swiss breed is in Switzerland, where it has been developed during many centuries. It is probably one of the oldest breeds in existence, and it is thought that no outside blood has been introduced since records began.

IMPORTATION AND DISTRIBUTION

The first importation of Brown Swiss into the United States was made in Massachusetts in 1869 and another in 1882. A number of importations have been made since, but only in small numbers. After 1906 there were only a few importations because of regulations

due to the prevalence of the foot-and-mouth disease in Europe. As shown in Tables 1 and 2, there are in the United States about 8,000 registered animals, and about 162,000 grades carrying more or less Brown Swiss blood. These are to be found scattered in 37 States, the largest numbers being in Wisconsin, Illinois, New York, Minnesota, Michigan, Iowa, Pennsylvania, and Ohio. Of late years the breed has made notable increase in popularity.

GENERAL CHARACTERISTICS

The large frame of the Brown Swiss cattle indicates that they have been developed for service as draft animals as well as for milk. They are substantial in appearance, well proportioned, with the body well covered with flesh. The calves weigh from 65 to 90 pounds at birth.

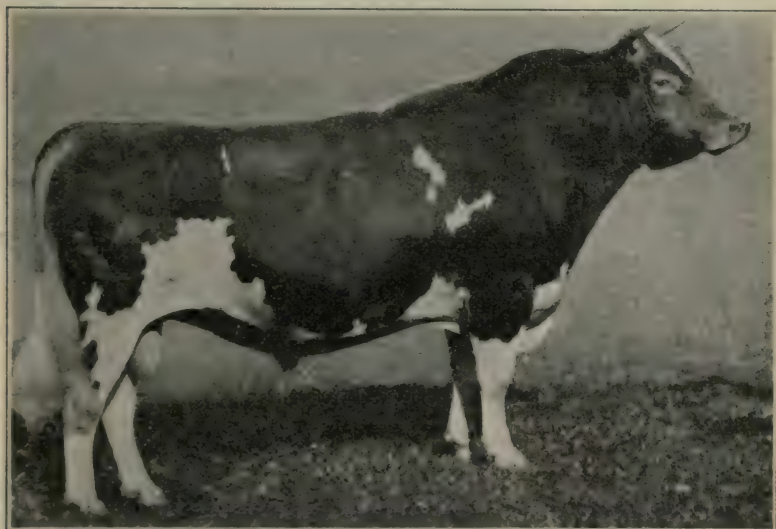


FIG. 6.—Brown Swiss bull, Reuben 2927. Twenty-three of his daughters are in the Advanced Registry

The heifers are slow in maturing. When full grown the cows weigh from 1,100 to 1,500 pounds, averaging about 1,250 pounds; and the bulls range in weight from 1,500 to 2,200 pounds, averaging about 1,750 pounds.

The color of the Brown Swiss varies from dark to light brown, and at some seasons of the year approaches gray. There is usually a light stripe of gray along the back. White splashes near the udder are found on some animals, but white splashes on the sides of the body or on the back are objectionable. The hair between the horns is usually a lighter shade than the body. The nose, switch, tongue, and horn tips are always black, and there is usually a light or mealy ring around the muzzle.



FIG. 7.—Brown Swiss bull, Ursula Stasis 10719. Grand champion, National Dairy Show, 1925

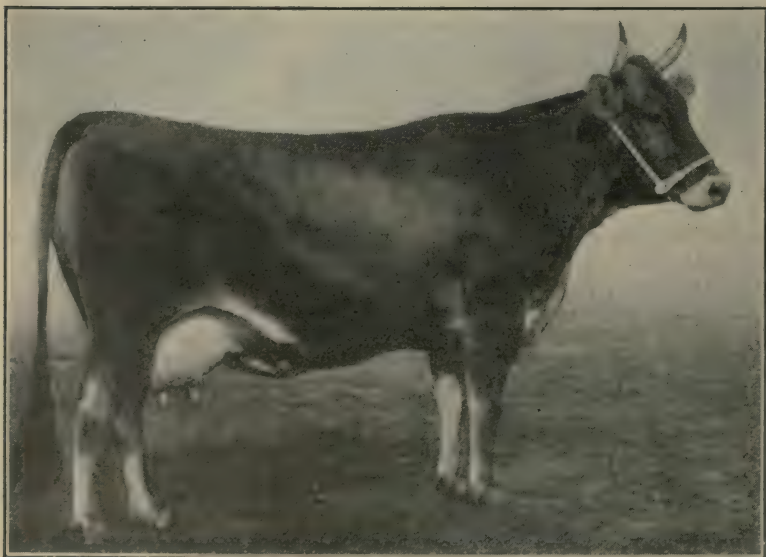


FIG. 8.—Brown Swiss cow, Hawthorn Dairy Maid 6753. One of the high producers of the breed



FIG. 9.—Brown Swiss cow, Believe 4245. World's champion of her breed in production of milk

Scale of points for Brown Swiss cow or heifer

Head, medium size and rather long.....	2
Face, dished, narrow between horns and wide between eyes.....	2
Ears, large, fringed inside with light-colored hair, skin inside of ear a deep orange color.....	2
Nose, black, large, and square, with mouth surrounded by mealy colored band, tongue black.....	2
Eyes, moderately large, full, and bright.....	2
Horns, short, regularly set with black tips.....	2
Neck, straight, throat clean, neatly joined to head, shoulders of good length, moderately thin at the withers.....	4
Chest, low, deep, and full between and back of forelegs.....	6
Back, level to setting of tail and broad across the loin.....	6
Ribs, long and broad, wide apart and well sprung, with thin, arching flanks.....	3
Abdomen, large and deep.....	5
Hips wide apart, rump long and broad.....	4
Thighs, wide, quarters not thin.....	4
Legs, short and straight, with good hoofs.....	2
Tail, slender, well set on, with good switch.....	2
Hide of medium thickness, mellow and elastic.....	3
Color—shades from dark to light brown, at some seasons of the year gray; white splashes near udder not objectionable, light stripe along back. White splashes on body or sides objectionable. Hair between horns usually lighter shade than body.....	4
Fore udder, wide, deep, well rounded but not pendulous nor fleshy, extending far forward on the abdomen.....	12
Rear udder, wide, deep, but not pendulous nor fleshy, extending well up behind.....	12
Teats, rather large, set well apart and hanging straight.....	8

Milk veins large, long, tortuous, elastic, and entering good wells.....	6
Disposition, quiet.....	2
Size, evidence of constitution, and stamina.....	5
Total.....	100

PRODUCTION

The Brown Swiss produces milk of average quality compared with the other breeds of dairy cattle. The 476 cows and heifers that completed yearly records and were admitted to the Register of Production up to January 1, 1926, have an average yearly production of 12,534 pounds of milk and 501.6 pounds of butterfat per cow, with an average butterfat test of 4 per cent. The 10 highest butterfat and milk producers among the Brown Swiss are listed below.

Ten highest Brown Swiss yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	<i>Pounds</i>		<i>Pounds</i>
June's College Girl 11427.....	1,062.30	Believe 4245.....	25,848
Believe 4245.....	1,002.62	Alice Lee 2d 8777.....	24,845
Hawthorn Dairy Maid 6753.....	927.23	Clothilda Werder's Aggie 10691.....	22,809
Alice Lee 2d 8777.....	914.38	Hawthorn Dairy Maid 6753.....	22,765
Clothilda Werder's Aggie 10691.....	880.22	Sterling Pride of Lake View 9530.....	22,597
Goldie Merrilan 12103.....	873.51	Goldie Merrilan 12103.....	22,093
Darling D. 8845.....	860.52	Belle Windsor of Tarpleywick 9000.....	21,211
Swiss Valley Girl 8th 6574.....	850.89	Hawthorn Dairy Maid 2d 8550.....	21,179
Hawthorn Dairy Maid 2d 8550.....	850.77	Swiss Valley Girl 8th 6574.....	20,812
Mary Dysart 6791.....	804.05	Darling D. 8845.....	20,275

BULLS

The 10 Brown Swiss sires having the largest number of daughters with official yearly records, up to January 1, 1926, are listed below.

Ten Brown Swiss sires having the largest number of daughters in Register of Production

Sire	Number of daughters	Sire	Number of daughters
Reuben 2927.....	23	Vogel's College Boy 5638.....	8
Junker 2365.....	10	Casper C. 1999.....	7
Collier 2075.....	10	Ben Hanson 2373.....	7
College Master 2986.....	10	Sunny Hill Bob 6170.....	7
Tom Phylis 1769.....	9	Merney's Second Son 3280.....	7

DUTCH BELTED

ORIGIN AND HISTORY

The Dutch Belted breed originated in Holland about two centuries ago. The breed gets its name both from the original home and from the distinctive color marking. This breed has probably been developed from the same cattle as the Holstein-Friesian. The early records show that the Dutch Belted were bred by the nobility of Holland, and while the unusual color marking was perhaps the chief basis of selection, the qualities of milk production and dairy refinement were not lost sight of.

IMPORTATION AND DISTRIBUTION

The first importation of Dutch Belted cattle into the United States was made probably in 1838. The first importation of importance, however, was made in 1840 by P. T. Barnum for show purposes. These cattle later were placed on a farm, and this seems to be the beginning of the Dutch Belted cattle in America. A number were imported from that time on until 1885, and some in 1906 and 1907. Since then no importations have been made on account of the prevalence of foot-and-mouth disease in Europe. As shown in Table 1, there are about 6,000 purebred Dutch Belted cattle in the United States, and about 150,000 grades.

GENERAL CHARACTERISTICS

Dutch Belted cattle have the general dairy conformation, which includes fineness of bone and freedom from beefiness. The aim of the breeders of these cattle is to breed animals that have no white other than that of the standard belt around the body. This belt begins back of the shoulder and may extend to the front of the hips but must not be narrower than 6 inches at the narrowest point. There must be no black spots in the belt on females. The width of the belt on each animal tends to be uniform around the body. The remainder of the animal is coal black except that females may have not to exceed 3 inches of white on hind feet above the hoof, and males may have not to exceed 2½ inches of white on one hind foot above the hoof.

Calves at birth range in weight from 60 to 90 pounds. Well-developed mature cows weigh from 1,000 to 1,500 pounds, averaging about 1,200 pounds; and bulls from 1,500 to 2,000 pounds, averaging about 1,700 pounds.

Scale of points for Dutch Belted cow

Body color, black, with a clearly defined continuous white belt. The belt to be of medium width, beginning behind the shoulder and extending nearly to the hips.....	8
Head, comparatively long and somewhat dishing; broad between the eyes. Poll, prominent; muzzle, fine; dark tongue.....	6
Eyes, black, full and mild. Horns long compared with their diameter.....	4
Neck, fine and moderately thin and should harmonize in symmetry with the head and shoulders.....	6
Shoulders fine at top, becoming deep and broad as they extend backward and downward, with a low chest.....	4
Barrel large and deep with well-developed abdomen; ribs well rounded and free from fat.....	10
Hips broad, and chine level, with full loin.....	10
Rump high, long, and broad.....	6
Hind quarters long and deep, rear line incurving; tail long, slim, tapering to a full switch.....	8
Legs short, clean, standing well apart.....	3
Udder large, well-developed front and rear; teats of convenient size and apart; mammary veins large, long, and crooked, entering large orifices.....	20
Escutcheon.....	2
Hair fine and soft; skin of moderate thickness of a rich, dark, or yellow color.....	3
Quiet disposition and free from excessive fat.....	4
General condition and apparent constitution.....	6

Perfection..... 100

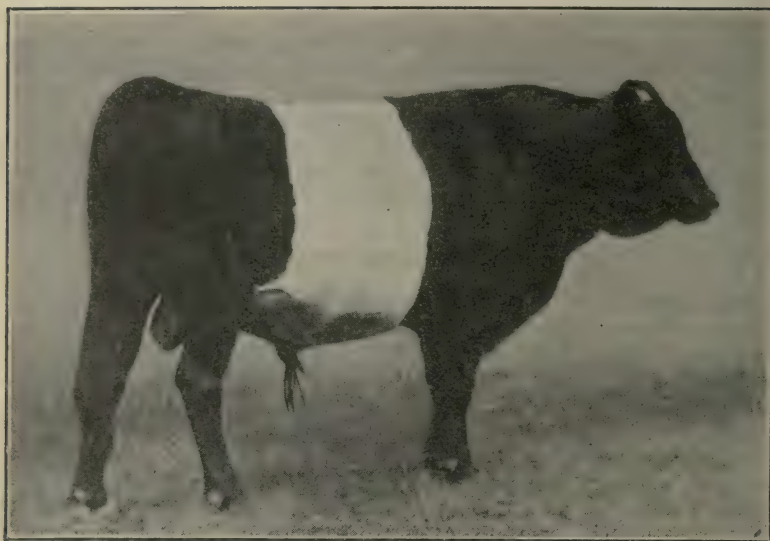


FIG. 10.—Dutch Belted bull, Keith 934. An Advanced-Register sire

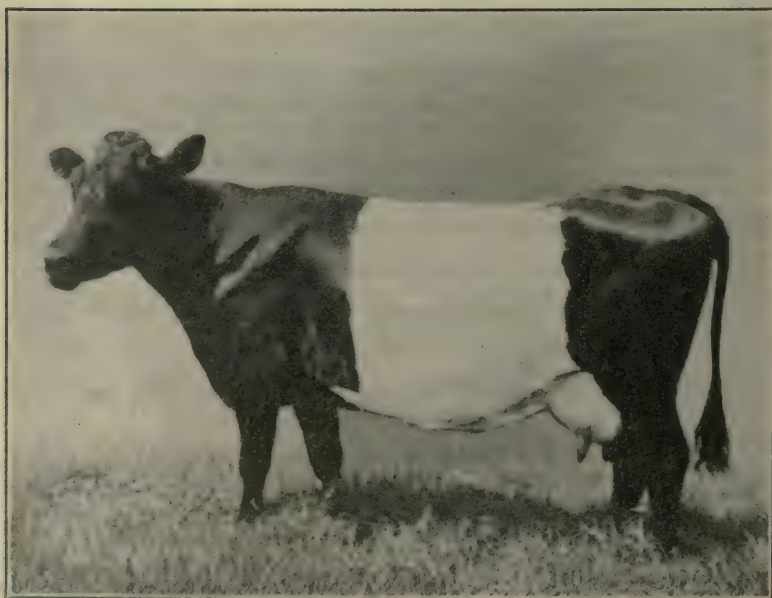


FIG. 11.—Dutch Belted cow, Gem of Columbia 2038. Leading milk producer of the breed

PRODUCTION

By referring to Table 3 it will be seen that the Dutch Belted cow ranks between the Holstein and the Ayrshire in the percentage of butterfat contained in her milk. The Dutch Belted cows and heifers that finished yearly official records up to January 1, 1926, show an average production of 10,141 pounds of milk and 384.64 pounds of butterfat, with an average test of 3.8 per cent.

The 10 highest producers of butterfat and milk among Dutch Belted cows are listed below.

Ten highest Dutch Belted yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	Pounds		Pounds
Angelina 2641.....	608.07	Gem of Columbia 2038.....	17,268
Gem of Columbia 2038.....	633.86	Angelina 2641.....	16,023
Glenbeulah's Beauty 2172.....	531.19	Ferndell 1961.....	13,478
Priscilla of Lakeview 2937.....	516.07	Priscilla of Lakeview 2937.....	13,385
Orange Lilly 3126.....	504.99	Glenbeulah's Beauty 2172.....	13,296
Ferndell 1961.....	501.09	Peapack Anna 1487.....	13,159
Peapack Anna 1487.....	484.31	Peapack Dutchess 1390, imported.....	13,065
Peapack Dutchess 1390, imported.....	447.64	Orange Lilly 3126.....	11,575
Fritzi 1832.....	435.79	Eunice 1597.....	11,479
Lily of the Dell 2450.....	434.10	Fritzi 1832.....	11,353

BULLS

The 10 Dutch Belted sires having the largest number of daughters, with official yearly records, up to January 1, 1926, are listed below.

Dutch Belted sires having two or more daughters with Advanced-Register official yearly records

Defendant 1185. Keith 634. Sutton's Gay Lad 494. Michigans Prince 1258.	Monarch of Lakeview 1219. Bruce W. 729. Samoset 1134.	Glenbeulah's Duke 1092. Columbia King 1015. Ka No No of Council Grove 1194.
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GUERNSEY

ORIGIN AND HISTORY

The Guernsey breed originated in the Channel Islands, near the north coast of France. It is thought that this breed has been developed from a cross between the large red and brindle cattle of Normandy and the small red cattle of Brittany, in France. The exact date of origin is unknown, but it was probably in the latter part of the seventeenth century or before.

All the cattle in the Channel Islands were at one time known as Alderneys. After laws had been enacted forbidding the importation of cattle from the Continent or between the islands of Guernsey and Jersey, two distinct breeds came to be recognized. The one on the islands of Alderney, Sark, and Guernsey became known as the Guernsey breed and the one on Jersey Island as the Jersey breed.



FIG. 12.—Guernsey bull, Yeoman's King of the May 17053. He has 103 daughters in the Advanced Registry



FIG. 13.—Guernsey bull, May Rose Cherub 70934. Grand champion, National Dairy Show, 1925

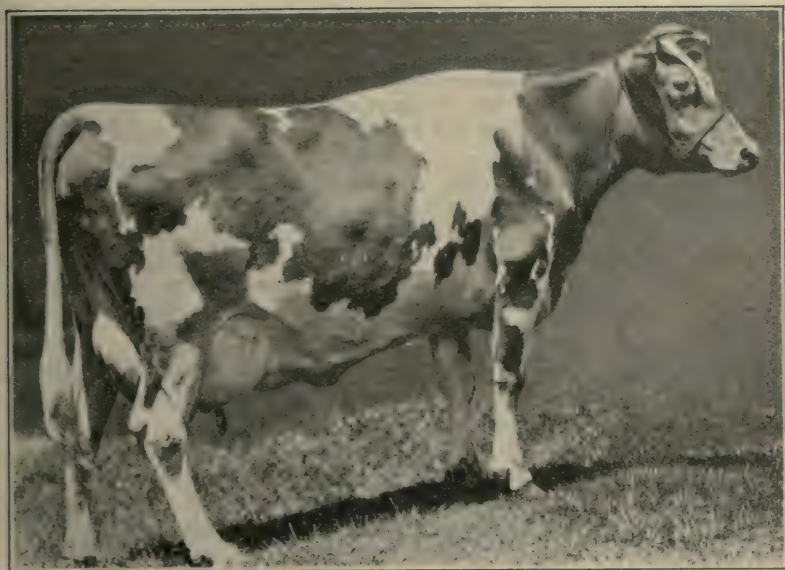


FIG. 14.—Guernsey cow, Anesthesia Faith of Hill Stead 114354. Champion butterfat producer of the breed



FIG. 15.—Guernsey cow, Murne Cowan 19597. Champion milk producer of the breed

IMPORTATION AND DISTRIBUTION

The first cattle from the Channel Islands brought to America were called Alderneys. They were imported in the latter part of the eighteenth century and may have been either Guernsey or Jersey cattle. The first animals recorded in the herdbook of the American Guernsey Cattle Club were brought over in 1830. A few more were imported in the next two decades, but not until about 1870 were extensive importations made. Since that time importations have been made nearly every year.

According to Tables 1 and 2, there are about 80,000 purebred Guernsey cattle in the United States, and about 1,900,000 grades. They are to be found in every State of the Union, but by far the largest numbers are found in the North Atlantic and North Central States.

GENERAL CHARACTERISTICS

In size the Guernseys are about equal to the Ayrshires and slightly smaller than the Brown Swiss. The calves weigh from 55 to 85 pounds at birth, and reach maturity early. When mature the cows weigh from 800 to 1,400 pounds, averaging about 1,050; and the bulls from 1,200 to 2,200 pounds, averaging about 1,600 pounds.

The color of the Guernseys is fawn and white, with fawn predominating. A light cherry red with white is also found. Sometimes white may be entirely lacking except on the legs. The switch is usually white and the tongue light in color. The horns are of moderate size and amber in color. The skin is yellow.

Scale of points for Guernsey cow

Style and symmetry, attractive individuality revealing vigor, femininity and breed character; a harmonious blending and correlation of parts; an active well-balanced walk.....	5
Head, moderately long, clean-cut, showing femininity and breed character; a lean face; wide mouth and broad muzzle with open nostrils; strong jaws; full bright eyes with gentle expression; forehead broad between the eyes and moderately dishing; bridge of nose straight.....	5
Horns, yellow, small at base; of medium length; inclining forward; not too spreading.....	1
Neck, long and thin; clean throat, smoothly blending into shoulders.....	2
Withers, chine rising above shoulder blades, with open vertebrae.....	2
Shoulders, shoulder blades set smoothly against chine and chest wall, forming neat junction with the body.....	2
Chest, wide, and deep at heart with least possible depression back of the shoulders.....	4
Back, appearing straight from withers to hips.....	5
Loin, strong, broad, and nearly level laterally; width carried forward to junction with the ribs.....	3
Hips, wide apart, approximately level with the back; free from excess tissue.....	2
Rump, long, continuing with level of the back; approximately level between hip bone and pin bones. Pin bones well apart.....	4
Thurls, wide apart and high.....	2
Barrel; deep and long with well-sprung ribs. Individual ribs: Long, flat, wide apart, and free from excess tissue.....	10
Thighs, incurving when viewed from side, thin and wide apart when viewed from rear; well cut up between the thighs.....	2
Legs, flat flinty bone, tendons clearly defined; front legs straight; hind legs nearly upright from hock to pastern, set wide apart and nearly straight when viewed from behind. Pastern: Strong and springy.....	2
Hide, loose and pliable, and not thick, with oily feelings; hair, fine and silky.....	3
Tail, long, tapering with neat, strong, level attachment, neatly set between pin bones; fine bone and hair; nicely balanced switch.....	2

Udder, uniformly fine in texture; free from meatiness; covered with pliable velvety skin.....	3
Veins prominent.....	1
Attachment to body: Strong, long, and wide.....	4
Extending well forward; extending well up behind.....	4
Sole: Level between teats.....	2
Teats: Of even convenient size; cylindrical in shape; well apart and squarely placed, plumb.....	3
Mammary veins, long, tortuous, prominent and branching with large numerous wells.....	3
Secretions indicating color of product, indicated by the pigment secretion of skin which should be a deep yellow inclining toward orange in color; especially discernible in the ear, at the end of bone of tail, around the eyes and nose, on the udder and teats, and at the base of horns; hoofs and horns amber colored.....	20
Color markings, a shade of fawn with white markings.....	2
Size, mature cows, about 1,100 pounds in milking condition.....	2
Total.....	100

PRODUCTION

Guernsey milk has a high per cent of butterfat and a yellow color.

The 20,931 cows and heifers that completed official records up to January 1, 1926, produced an average per cow of 9,615.2 pounds of milk and 480.1 pounds of butterfat, the average fat test being 4.99 per cent.

The 10 highest butterfat and milk producers among the Guernseys are listed below.

Ten highest Guernsey yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	<i>Pounds</i>		<i>Pounds</i>
Anesthesia Faith of Hill Stead 114354.....	1, 112. 50	Murne Cowan 19597.....	24, 008
Countess Prue 43785.....	1, 103. 28	Katherine's Trixie 100396.....	21, 071
Murne Cowan 19597.....	1, 098. 18	Gertrude Claire 99550.....	20, 738
May Rima 22761.....	1, 073. 41	Nella Jay 4th 38233.....	20, 710
Gertrude Claire 99550.....	1, 020. 00	Molly's Lassie 86472.....	20, 592
Nella Jay 4th 38233.....	1, 019. 25	Miss Daisy of Maple Hill 72610.....	20, 315
Langwater Nancy 27943.....	1, 011. 66	Tom's Daisy 54541.....	20, 298
Dairy Maid Queen of Spring Hill 74067.....	1, 011. 18	Jean Du Luth Coronet 52816.....	20, 004
Langwater Hope 27946.....	1, 003. 17	Langwater Hope 27946.....	19, 882
Lillia of Iowa 2d 61500.....	998. 40	Yeksa's Top's of Gold's Fannie 22362.....	19, 795

BULLS

The 10 Guernsey sires having the largest number of daughters with official yearly records, up to January 1, 1926, are listed below.

Ten Guernsey sires having the largest number of Advanced-Register daughters

Sire	Number of daughters	Sire	Number of daughters
Governor of the Chêne (R. G. A. S. 1297 P. S.).....	114	Galaxy's Sequel 16904 (Imp.).....	53
Yeoman's King of the May 17053.....	103	Ne Plus Ultra 15295.....	48
Langwater Demonstrator 16451.....	71	Cora's Governor of Chilmarnock 8971 (Imp.).....	47
Masher's Sequel 11462 (Imp.).....	70	Beda's May King 11893.....	45
Clara's Sequel 29414 (Imp.).....	58	Florham Laddie 20431.....	42

HOLSTEIN-FRIESIAN

ORIGIN AND HISTORY

The cattle from which our present Holstein-Friesian breed has descended were developed in northern Holland, especially in the Province of Friesland, and in the neighboring Provinces of northern Germany. The time of their origin as a recognized distinct breed is unknown, but it is probable that they have been selected for their dairy qualities for about 2,000 years.

Before 1885 there were two associations furthering the interests of this breed in the United States. One maintained a Holstein herdbook, and the other a Dutch-Friesian herdbook. In 1885 the two associations were combined into the Holstein-Friesian Association of America, and from that time on only one herd register has been maintained. This is known as the Holstein-Friesian herdbook. While the official name of the breed is Holstein-Friesian, the single word Holstein is more common in ordinary use.

IMPORTATION AND DISTRIBUTION

The first importations of Holsteins into the United States were made in 1795, and afterwards a few were brought in from time to time up to 1879, following which heavy importations were made each year until 1887. Thereafter only a few were imported up to 1905, and since then, because of the prevalence of foot-and-mouth disease in Europe, very few have been imported.

According to Tables 1 and 2 there are about 528,000 purebred Holsteins in the United States, and about 10,500,000 grades. Holstein cattle are found throughout all the 48 States of the Union, though by far the largest numbers are in New York, Wisconsin, Pennsylvania, Ohio, Michigan, and Illinois, in the order named. These six States contain more than 60 per cent of the purebred Holstein cattle in the United States.

GENERAL CHARACTERISTICS

The Holsteins are the largest of the dairy breeds. They have large frames, not heavily covered with flesh. The calves weigh from 70 to 105 pounds at birth. The mature bulls weigh from 1,600 to 2,200, and average about 1,900 pounds; and the mature cows weigh from 1,100 to 1,750, and average about 1,250 pounds. The color is black and white, with the colors sharply defined rather than blended. They may be nearly all white or black, but no solid-color animal can be registered.

Scale of points for Holstein-Friesian cow

Forehead, broad between the eyes; dishing.....	2
Face, of medium length; clean cut; feminine; the bridge of the nose straight.....	1
Muzzle, broad, with strong lips; nostrils, large and open; jaws strong.....	3
Ears, of medium size; of fine texture; well carried.....	1
Eyes, large; full; mild; bright.....	2
Horns, small; tapering finely toward the tips; set moderately narrow at base; inclining forward; well curved inward.....	1
Neck, long; fine and clean at junction with the head; evenly and smoothly joined to shoulder.....	3
Shoulders, slightly lower than the hips; smooth and rounding over tops; moderately broad and full at sides.....	3

Crops, full; level with the shoulders.....	5
Chine, straight; strong; broadly developed, with open vertebrae.....	4
Loin and hips, broad; level or nearly level between the hip bones; level and strong laterally; spreading from chine broadly and nearly level; hip bones fairly prominent.....	6
Rump, long; broad with roomy pelvis; nearly level laterally; full above the thurls; carried out straight to tail head.....	6
Pin bones, wide between; nearly level with hips.....	2
Thurls, high; broad through.....	2
Tail head and tail, strong at base without coarseness; the setting well back; tail long, tapering finely to a full switch.....	2
Chest, deep; wide; well filled and smooth in the brisket; broad between the forearms; full in the foreflanks.....	6
Barrel, long; deep; well rounded; strongly and trimly held up.....	9
Flanks, deep; full.....	2
Thighs, wide; deep; straight behind; wide and moderately full at the outside; twist well cut out and filled with development of udder; escutcheon well defined.....	2
Mammary veins, large, tortuous, entering large orifices or double extension; with additional developments, such as branches and connections entering numerous orifices.....	8
Udder, capacious; flexible; quarters even and of uniform texture, filling the space in the rear below the twist, extending well forward; broad and well attached.....	14
Teats, well formed; plumb; of convenient size; properly placed.....	4
Legs, medium length; clean; nearly straight; wide apart; firmly and squarely set under the body; arms wide, strong, and tapering.....	4
Hair and hide, hair healthy in appearance; fine and soft; hide of medium thickness; mellow and loose.....	8
Total.....	100

PRODUCTION

The Holsteins produce a larger quantity of milk, with a lower butterfat content, than any other dairy breed. The milk is not so highly colored as that from the Guernseys and Jerseys.

The 23,622 official records of Holstein cows and heifers that were completed up to January 1, 1926, show an average yearly production of 15,697 pounds of milk and 532.44 pounds of butterfat, the average test being 3.39 per cent.

The 10 highest butterfat and milk producers among the Holsteins are listed below.

Ten highest Holstein yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	<i>Pounds</i>		<i>Pounds</i>
De Kol Plus Segis Dixie 295135 ¹	1,349.31	Segis Pietertje Prospect 221846	37,381
May Walker Olive Homestead 300043	1,218.50	Helm Veeman Woodeast 486877	36,218
Hollywood Lillith Palmyra Abbekerk 400491	1,206.79	Kolrain Marion FINDERNE 317396	35,340
Duchess Skylark Ormsby 124514	1,205.09	Kolrain FINDERNE Bess 291570	35,085
Bess Johanna Ormsby 293431	1,198.09	Nooksack Lunde Oregon De Kol 301119	34,511
FINDERNE Pride Johanna Rue 121093	1,176.47	Queen Carlotta De Kol 311674	34,430
Segis Pietertje Prospect 221846	1,158.95	Adirondac Wietske Dairy Maid 204072	34,402
Dutchland Pietertje Creamelle 394861	1,148.54	Grahamholm Colantha Pauline Segis 405465	34,292
Grahamholm Colantha Pauline Segis 405465	1,141.40	Princess Anggie Polkadot De Kol 372024	34,071
Adirondac Wietske Dairy Maid 204072	1,136.15	Grahamholm Colantha Segis Maid 405466	33,812

¹ Canadian cow.



FIG. 16.—Holstein bull, Sir Pietertje Ormsby Mercedes 44931. He has 65 yearly-record daughters in the Advanced Register



FIG. 17.—Holstein bull, Johanna Rag Apple Pabst 346005. Grand champion, National Dairy Show, 1925



FIG. 18.—Holstein cow, Segis Pietertje Prospect 221846. Has highest yearly milk record of all the breeds



FIG. 19.—De Kol Plus Segis Dixie 295135. Has highest yearly butterfat record of all the breeds (Canadian cow)

BULLS

The 10 Holstein-Friesian sires having the largest number of daughters with yearly records, up to January 1, 1926, are listed below.

Ten Holstein sires with the largest number of yearly-record daughters

Sire	Number of daughters	Sire	Number of daughters
Sir Inka Prilly Segis 80914.....	71	Sir Pietertje Ormsby Mercedes 44931.....	65
Judge Segis 80912.....	67	Woodcrest Tehee 74219.....	62
Sir Johanna Fayne 42147.....	67	Colantha Sir Walker Korndyke 95460.....	60
King Pontiac Champion 53418.....	65	King of the Pontiacs 39037.....	52
Matador Segis Walker 148839.....	65	Ormsby Korndyke Lad 102469.....	51

JERSEY

ORIGIN AND HISTORY

The Jersey breed originated in the Island of Jersey, one of the group of Channel Islands, between England and France. In 1789 a law was passed prohibiting the importation of cattle into Jersey Island except for immediate slaughter. Shortly afterwards the cattle on that island became known by the name of Jersey instead of Alderney. No outside blood has been introduced since that time.

IMPORTATION AND DISTRIBUTION

The first importation of Jerseys into the United States was made in 1850. A few more were brought over about 20 years later, and from 1870 to 1890 there were numerous importations. Since 1890 many Jerseys have been imported every year.

The Jerseys are more evenly distributed in the United States than any other breed. There were about 232,000 purebred and about 9,300,000 grade Jerseys in this country in 1920, well scattered throughout all the 48 States.

GENERAL CHARACTERISTICS

The Jersey is the smallest of the breeds discussed in this bulletin. The calves weigh from 40 to 75 pounds at birth. The heifers develop rapidly and mature sufficiently to drop the first calf at 24 months of age. The mature cows weigh from 700 to 1,200 pounds, averaging about 900 pounds, and the bulls weigh from 1,200 to 1,800, averaging about 1,500 pounds.

The color of Jerseys is usually some shade of fawn or cream color, though different shades of mouse color, gray, and brown are common, and some individuals approach black. They may be solid color of any of these shades, or spotted with white. The muzzles and tongues are usually black or lead colored, but light-colored tongues are not uncommon, and around the muzzle is a white or mealy ring.



FIG. 20.—Jersey bull, Pegis 99th of Hood Farm 94502. He has 111 daughters in the Register of Merit



FIG. 21.—Jersey bull, Fern's Rochett Noble 193011. Grand champion, National Dairy Show, 1925



FIG. 22.—Jersey cow, Madeline of Hillside 389336. Champion milk producer of the breed



FIG. 23.—Jersey cow, Darling's Jolly Lassie 435948. Champion butterfat producer of the breed

Scale of points for Jersey cow

DAIRY TEMPERAMENT AND CONSTITUTION

Head, 7:	
A. Medium size, lean; face dished; broad between eyes; horns medium size, incurving.....	3
B. Eyes full and placid; ears medium size, fine, carried alert; muzzle broad, with wide-open nostrils and muscular lips; jaw strong....	4
Neck, 4:	
Thin, rather long, with clean throat, neatly joined to head and shoulders..	4
Body, 37:	
A. Shoulders light, good distance through from point to point, but thin at withers; chest deep and full between and just back of forelegs..	5
B. Ribs amply sprung and wide apart, giving wedge shape, with deep, large abdomen, firmly held up, with strong, muscular development..	10
C. Back straight and strong, with prominent spinal processes; loins broad and strong.....	5
D. Rump long to tail setting, and level from hip bones to rump bones..	6
E. Hip bones high and wide apart.....	3
F. Thighs flat and wide apart, giving ample room for udder.....	3
G. Legs proportionate to size and of fine quality, well apart, with good feet, and not to weave or cross in walking.....	2
H. Hide loose and mellow.....	2
I. Tail thin, long, with good switch, not coarse at setting on.....	1

MAMMARY DEVELOPMENT

Udder, 26:	
A. Large size, flexible, and not fleshy.....	6
B. Broad, level or spherical, not deeply cut between teats.....	4
C. Fore udder full and well rounded, running well forward of front teats..	10
D. Rear udder well rounded, and well out and up behind.....	6
Teats, 8:	
Of good and uniform length and size, regularly and squarely placed....	8
Milk veins, 4:	
Large, long, tortuous and elastic, entering large and numerous orifices..	4
Size, 4:	
Mature cows, 800 to 1,000 pounds.....	4
General appearance, 10:	
A symmetrical balancing of all the parts, and a proportion of parts to one another, depending on size of animal, with the general appearance of a high-class animal, with capacity for feed and productiveness at pail..	10
Total score.....	100

PRODUCTION

Jersey milk is yellow and rich in butterfat. The 22,355 cows and heifers that had Register-of-Merit records up to January 1, 1925, averaged 8,287 pounds of milk and 444.37 pounds of butterfat a year, with an average test of 5.36 per cent.

The 10 highest butterfat and milk producers among the Jerseys are listed below.

Ten highest Jersey yearly butterfat and milk production records in the United States

Butterfat production		Milk production	
Cow	Butterfat	Cow	Milk
	<i>Pounds</i>		<i>Pounds</i>
Darling's Jolly Lassie 435948.....	1, 141. 28	Madeline of Hillside 389336.....	20, 624
Groff's Constance 367292.....	1, 130. 09	Fauvic's Star 313018.....	20, 616
Prince's Emma of H. S. F. 359390.....	1, 109. 99	Abigail of Hillside 457241.....	20, 359
Lad's Iota 350672.....	1, 048. 07	Passport 219742.....	19, 695
Fauvie Ruth 385463.....	1, 047. 28	Lad's Likeness 338246.....	19, 223
Madeline of Hillside 389336.....	1, 044. 05	Eminent's Jimp's Owl 297471.....	19, 099
Plain Mary 268206.....	1, 040. 08	St. Mawes Blossom Rosaire 355800.....	19, 061
Vive La France 319616.....	1, 039. 29	Miss Inez 377204.....	18, 917
Lady's Silken Glow 313311.....	1, 038. 70	Raleigh's Sybil 372752.....	18, 847
St. Mawes Lad's Lady 451568.....	1, 032. 97	Eminent's Bess 209719.....	18, 783

BULLS

The 10 Jersey sires having the largest number of daughters with official yearly records, up to January 1, 1925, are listed below.

Ten Jersey sires with largest number of daughters in Register of Merit

Sire	Number of daughters	Sire	Number of daughters
Pogis 99th of Hood Farm 94502.....	111	Sophie 19th's Tormenor 113302.....	73
Imported Oxford You'll Do 111860.....	83	Dairylike Majesty 198188.....	72
Royal Majesty of St. Cloud 89541.....	82	Imported Golden Fern's Noble 145762.....	65
Hood Farm Pogis 9th 55552.....	79	Irene's King Pogis 73182.....	62
Hood Farm Toronto 60326.....	74	Sayda's Heir 3d 74817.....	62

BREED ASSOCIATIONS

The various breed associations and clubs maintain offices and forces whose duty it is (1) to keep the herdbooks for their respective breeds; (2) to keep a record of the animals that have qualified for the additional registration because of meritorious performance; and (3) to further the interest of the breed in other ways. The official names of these organizations and their addresses are as follows:

American Guernsey Cattle Club, Peterboro, N. H.

American Jersey Cattle Club, 324 West Twenty-third Street, New York City.

Ayrshire Breeders' Association, Brandon, Vt.

Brown Swiss Cattle Breeders' Association, Beloit, Wis.

Dutch Belted Cattle Association of America, Rockville, Conn.

Holstein-Friesian Association of America, Brattleboro, Vt.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1444

GAME LAWS

FOR THE SEASON

1924-25

*A Summary of the Provisions
of Federal, State, and Provincial
Statutes*



THE twenty-fifth annual summary by the Department of Agriculture of Federal and other game laws and regulations is here presented for the use of law-enforcement officials, sportsmen, conservationists, and others, as an aid in the administration of the migratory-bird treaty and Lacey Acts. The provisions as set forth furnish a brief and convenient synopsis of the laws. Provisions relating to methods of capture, game refuges, enforcement of laws, disposition of fees and fines, and minor matters are omitted, as also are tests of Federal and Canadian laws and regulations relating to birds and game.

Washington, D. C.

Issued August, 1924.

OFFICIALS FROM WHOM COPIES OF GAME LAWS MAY BE OBTAINED

- Alabama:** Department of Game and Fisheries, Montgomery.
- Alaska:** Chief Alaska Game Warden, Juneau; Secretary of Agriculture, Washington, D. C.
- Arizona:** State Game Warden, Phoenix.
- Arkansas:** Secretary, Game and Fish Commission, Little Rock.
- California:** Executive Officer, Fish and Game Commission, Forum Building, Sacramento.
- Colorado:** State Game and Fish Commissioner, Denver.
- Connecticut:** Superintendent of Fisheries and Game, Hartford.
- Delaware:** Chief Game Warden, Dover.
- District of Columbia:** Superintendent Metropolitan Police, Washington.
- Florida:** Secretary of State, Tallahassee.
- Georgia:** Game and Fish Commissioner, Atlanta.
- Hawaii:** Fish and Game Commission, Honolulu.
- Idaho:** Fish and Game Warden, Boise.
- Illinois:** Chief Game and Fish Warden, Springfield.
- Indiana:** Superintendent, Division of Fisheries and Game, State House, Indianapolis.
- Iowa:** State Fish and Game Warden, Lansing.
- Kansas:** State Fish and Game Warden, Pratt.
- Kentucky:** Executive Agent, Game and Fish Commission, Frankfort.
- Louisiana:** Commissioner of Conservation, Court Building, New Orleans.
- Maine:** Commissioner of Inland Fisheries and Game, State House, Augusta.
- Maryland:** State Game Warden, 514 Munsey Building, Baltimore.
- Massachusetts:** Director, Division of Fisheries and Game, State House, Boston.
- Michigan:** Director, Department of Conservation, Lansing.
- Minnesota:** Game and Fish Commissioner, St. Paul.
- Mississippi:** Secretary of State, Jackson; and Sheriff or County Clerk.
- Missouri:** Game and Fish Commissioner, Jefferson City.
- Montana:** State Fish and Game Warden, Helena.
- Nebraska:** Chief Fish and Game Warden, Lincoln.
- Nevada:** Secretary, State Fish and Game Commission, Reno.
- New Hampshire:** Fish and Game Commissioner, Concord.
- New Jersey:** Secretary, Board of Fish and Game Commissioners, Trenton.
- New Mexico:** Game and Fish Warden, Santa Fe.
- New York:** Secretary, Conservation Commission, Albany.
- North Carolina:** Secretary, Audubon Society of North Carolina, Raleigh; or Legislative Reference Librarian, Raleigh.
- North Dakota:** Secretary, Game and Fish Board, Minnewaukan.
- Ohio:** Chief Game Warden, Board of Agriculture, Columbus.
- Oklahoma:** State Game Warden, Oklahoma City.
- Oregon:** State Game Warden, Portland.
- Pennsylvania:** Executive Secretary, Board of Game Commissioners, Harrisburg.
- Rhode Island:** Chairman, Commissioners of Birds, Providence.
- South Carolina:** Chief Game Warden, Columbia.
- South Dakota:** State Game Warden, Pierre.
- Tennessee:** State Game and Fish Warden, Department of Agriculture, Nashville.
- Texas:** Game, Fish, and Oyster Commissioner, Austin.
- Utah:** Fish and Game Commissioner, Salt Lake City.
- Vermont:** Fish and Game Commissioner, Montpelier.
- Virginia:** Commissioner of Game and Inland Fisheries, Richmond.
- Washington:** Supervisor of Game and Game Fish, Box 384, Seattle.
- West Virginia:** Game and Fish Commission, Charleston; or Chief Game Protector, Buckhannon.
- Wisconsin:** Conservation Commissioner, Madison.
- Wyoming:** State Game and Fish Commissioner, Cheyenne.
- Dominion of Canada Legislation:** Commissioner, Canadian National Parks, Ottawa.
- Alberta:** Chief Game Guardian, Edmonton.
- British Columbia:** Secretary, Game Conservation Board, Vancouver.
- Manitoba:** Chief Game Guardian, Winnipeg.
- New Brunswick:** Chief Game and Fire Warden, Fredericton.
- Northwest Territories:** Director, Northwest Territories, Ottawa.
- Nova Scotia:** Commissioner of Forests and Game, Halifax.
- Ontario:** Superintendent of Game and Fisheries, Toronto.
- Prince Edward Island:** Deputy Federal Migratory Bird Officer, Charlottetown.
- Quebec:** General Superintendent of Fisheries and Game, Quebec.
- Saskatchewan:** Chief Game Guardian, Regina.
- Yukon:** Gold Commissioner, Dawson.
- Colony of Newfoundland:** Secretary, Game and Inland Fisheries Board, St. John.
- Mexico:** Chief of the Game Department in Administration of Forestry and Game, Secretario de Fomento, City of Mexico.
- Lower California: (Northern District):** The Governor, Tijuana.

This bulletin is a contribution from

Bureau of Biological Survey

Division of Migratory Bird Treaty and Lacey Acts

E. W. NELSON, Chief.

GEO. A. LAWYER, Chief United States Game Warden, in charge.

GAME LAWS FOR THE SEASON 1924-25

A SUMMARY OF FEDERAL, STATE, AND PROVINCIAL STATUTES

By GEO. A. LAWYER, *Chief United States Game Warden*, and FRANK L. EARN-SHAW, *Assistant, Interstate Commerce in Game, Division of Migratory Bird Treaty and Lacey Acts, Bureau of Biological Survey*

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REVIEW OF LEGISLATION OF 1924

Since the bulletin on the game laws for the season 1923-24 was issued, legislative sessions have been held in Alabama, Georgia,¹ Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, Rhode Island, South Carolina, and Virginia, and few changes in the game laws were made.

FEDERAL LEGISLATION

Several bills extremely important to wild-life conservation, including the migratory bird refuge bill (S. 2913—H. R. 745), the Alaska game bill (S. 2559—H. R. 5949), the Upper Mississippi River wild life and fish refuge bill (S. 1558—H. R. 4088), and the resolution transferring jurisdiction over game in Alaska to the Department of Agriculture (S. J. Res. 127), were introduced in the first session of the Sixty-eighth Congress. The migratory bird refuge bill was favorably reported by the committees of both Senate and House and is on the calendar. The Alaska game bill passed the Senate and is still pending in the House.

The Upper Mississippi River wild life and fish refuge bill was passed and became a law on June 7, 1924. This act authorizes the acquisition and setting aside, as a wild life refuge, of about 300,000 acres of swamp and low lands along the Mississippi River between Rock Island, Ill., and Wabasha, Minn. After these areas have been acquired by the Government, the Secretary of Agriculture will have jurisdiction with respect to game birds, game animals, and fur-bearing animals, and the Secretary of Commerce will have jurisdiction over the fish and other aquatic animal life, and suitable regulations by the two departments are authorized to govern hunting and fishing on the areas to be acquired. The act carries no appropriation for the purchase of lands, but authorizes an appropriation of \$1,500,000 to be made for the purpose.

Jurisdiction over game in Alaska, heretofore exercised by the Governor of the Territory, under the Department of the Interior, was transferred to the Department of Agriculture, by joint resolution approved by the President on June 7, 1924, thus giving this department complete control of the administration, through the Biological Survey, of the laws relating to game and land fur-bearing animals in Alaska. The consolidation of these services will coordinate the work and bring about greater efficiency, and should mean a more economical expenditure of Government funds, thereby promoting the conservation and perpetuation of game and fur resources in the Territory.

¹ The legislature of Georgia did not convene until late in June, and at the time of going to press no information was available concerning action taken on game matters.

The Federal law (sec. 84, Criminal Code) prohibiting the killing or disturbing of wild birds on national bird reservations was amended by act of April 15, 1924, to afford protection to all wild animals and property of the United States on Federal bird and game reservations.

Other acts passed authorize the President to withdraw from entry approximately 25,000 acres of public land in South Dakota, which the State may fence and use as an antelope and game refuge, and to set aside 16,000 acres of public lands as an addition to the Custer State Park game sanctuary in South Dakota, making a total of 46,000 acres—30,000 acres having been withdrawn under the act of June 5, 1920.

Of the utmost interest to outdoor enthusiasts and others who for years have urged the enactment of appropriate legislation to check the ever-increasing menace to wild life by oil and other forms of pollution which have contaminated our coastal and inland waters, destroyed aquatic life therein, and seriously endangered the public health, is the oil-pollution bill, which became a law on June 7, 1924. This act prohibits any vessel using oil as fuel for the generation of propulsion power or any vessel carrying or having oil thereon in excess of that necessary for its lubricating requirements, from discharging oil, oil sludge, or oil refuse into the coastal navigable waters, including all inland navigable waters in which the tide ebbs and flows. The Secretary of War is empowered to make regulations permitting the discharge of oil from vessels under conditions which will not be deleterious to health or sea food or a menace to navigation. Officials of the Customs and Coast Guard Services are required to cooperate with the Secretary of War in the enforcement of the act. The Secretary of War also is directed to ascertain the sources and substances of pollution in navigable waters, including nonnavigable waters connected therewith, which endanger navigation, commerce, or fisheries, and to report to Congress within two years the results of his investigations, together with recommendations for remedial legislation.

Congress also passed, and the President approved, the Clarke-McNary Reforestation Act providing for the protection of forest lands, reforestation of denuded areas, the extension of national forests, and the protection of watersheds of navigable streams. In addition to its main purposes, the passage of this legislation should result in much benefit to the game on the affected areas.

A close season for two years on all game animals in the Lower Taku River district, Alaska, was prescribed by regulations of the Department of Agriculture. This was designed primarily to protect the moose in that section, and also reduced from two to one the season limit on moose south of latitude 62°, and shortened the season 12 days.

MIGRATORY BIRDS

The migratory bird treaty act regulations were amended, effective April 11, 1924, by fixing October 16 to January 31 in Mississippi and November 1 to January 31 in Louisiana as the open seasons on doves. The former season on doves in these States extended from September 16 to December 31. The regulations were also amended, effective July 2, 1924, by making the open season on migratory waterfowl (except wood ducks, eider ducks, and swans), coot, gallinules, and Wilson snipe or jacksnipe September 24 to January 7 (instead of September 16 to December 31) in New York, except on Long Island. This amendment harmonizes the Federal season on waterfowl with the season fixed by State law at the 1924 session of the legislature, but creates a conflict between Federal and State seasons on coot, gallinules, and Wilson snipe, as a result of which birds of these species may be taken only from September 24 to December 31 without violating either Federal or State laws.

Substantial progress was made in further harmonizing State laws on migratory birds with the Federal regulations. In Virginia and Alabama the State laws were made to conform in their entirety, in Maryland the season on waterfowl, and in Iowa the seasons on all migratory game birds were made to conform with the Federal regulations. Iowa reduced from 25 to 15 the daily limit on each species, and Virginia also prescribed season limits on all species of migratory game birds.

Maryland prohibited the discharge of firearms on the roosting or feeding grounds of rail and bobolinks, or reedbirds, during August, thus preventing the disturbance of these birds prior to the opening of the season by gunners who are in the marshes under the guise of hunting blackbirds, which are unprotected. The boundary line of the Susquehanna Flats was extended to a point near Charleston on Northeast River, in Cecil County, thus considerably increasing the area formerly designated as the Flats. Maryland also reenacted the law repealed

in 1922 prohibiting the presence of craft or the setting of decoys on the Susquehanna Flats prior to 4.30 a. m. on regular gunning days.

New Jersey modified its law prohibiting the baiting of waterfowl with grain, other than wild celery or wild rice, so as to permit baiting more than 400 feet from gunning points.

SMALL UPLAND GAME

In Alabama the open season on quail was shortened four weeks; on ruffed grouse and introduced game birds it was closed until 1927; and on squirrels it was shortened approximately seven weeks by opening on November 1 instead of September 15.

Virginia established a uniform season from November 15 to January 31 on quail, ruffed grouse, wild turkeys, rabbits, and squirrels and abolished the special seasons heretofore existing on upland game birds east and west of the Blue Ridge Mountains. The season is thus shortened two weeks east, but lengthened two weeks west of the ridge. The daily limit on grouse was reduced from 6 to 4, and season limits of 20 grouse, 6 wild turkeys, and 150 quail were prescribed.

New Jersey fixed a daily limit of 6 on squirrels, and reduced it from 10 to 6 on rabbits.

Alberta lengthened the season two weeks on grouse, prairie chickens, and ptarmigan by allowing shooting during the full month of October, and fixed the open season on Hungarian partridge as the period from September 15 to November 15, instead of the month of November. Bag limits on Hungarian partridge were increased from 10 to 15 a day and from 50 to 75 a season. Ontario lengthened the season on ruffed grouse three weeks in the region south of the French and Mattawa Rivers, thus making it uniform throughout the Province.

BIG GAME

Manitoba prohibited the taking of male antelope at any time, thus protecting the species throughout the Province. This, together with recent action in Mexico closing the season on antelope until 1932, removes this species from the game list throughout its range.

A buck law permitting the killing of deer with horns visible above the hair, with a limit of one a day and two a season, was enacted in Virginia.

In South Carolina the season on deer was lengthened 15 days, but the limit was reduced from five to three, and the season on bear was shortened two and one-half months.

By order of the State game commission, deer hunting was suspended in West Virginia this season.

In Nova Scotia, Inverness and Victoria Counties were closed until 1930 to the shooting of bull caribou, thus closing the entire Province. The sale of moose meat was also prohibited.

Further protection was afforded musk-oxen in the Northwest Territories by regulation prohibiting their killing except under a permit; this deprives Indians and Eskimos of their former privilege of killing these animals at any time for food purposes.

GAME AND BIRD REFUGES

The President reestablished the Blackbeard Island Reservation, Georgia, by Executive order dated February 25, 1924; this was originally created July 17, 1914, and vacated May 25, 1915.

Manitoba created the West Shoal Lake Refuge with an area of 37 sections, and the Shoal Lake Refuge of 6 sections.

In the Northwest Territories there have been reserved for hunting and trapping exclusively by native Indians, Eskimos, and halfbreeds 6 areas including Victoria Island, 74,400 square miles; Banks Island, 26,400 square miles; Peel River Preserve, 3,300 square miles; Yellowknife Preserve, 70,000 square miles; Slave River Preserve, 2,200 square miles; and Backs River Preserve, 65,500 square miles.

In Saskatchewan the Dunburn Game Preserve with an area of 63 square miles was created.

MISCELLANEOUS

Alabama reorganized the department of conservation as the department of game and fisheries and increased the salary of the commissioner from \$3,000 to \$4,000 per annum. The fee for a nonresident license was increased from \$15 to \$25.

Iowa increased the term of the State game warden from three to four years, and now requires the appointment to be approved by the Senate.

Virginia requires a resident of a State having a larger nonresident hunting license fee than that charged in Virginia to pay the fee charged in own State. Violation of hunting, trapping, or fishing laws in Virginia works a forfeiture of license privileges for a period of 12 months following conviction.

In the Northwest Territories a \$5 license is required of nonresidents to hunt birds.

Mexico has recently taken several important steps toward the conservation of game. These include the prohibition of killing of antelope and mountain sheep, and the shipment of quail except under special permit. Brief reference is made to the provisions of the Mexican laws and regulations, and also to the requirement of hunting licenses, in a summary following the statement of Canadian laws.

SUMMARY OF LAWS RELATING TO SEASONS, LICENSES, LIMITS, POSSESSION, INTERSTATE TRANSPORTATION, AND SALE

The dates of open seasons for migratory game birds shown under the various States and Provinces are the times when these birds may be hunted without violating either State laws or Federal regulations.² Federal regulations prohibit their shooting from sunset to half an hour before sunrise, and prohibit the killing of the following birds at any time:

Band-tailed pigeon; little brown, sandhill, and whooping cranes; wood duck, eider ducks, swans; curlews, willet, upland plover, and all shorebirds (except the black-bellied and golden plovers, Wilson snipe or jacksnipe, woodcock, and the greater and lesser yellowlegs); cuckoos; flickers and other woodpeckers; nighthawks, or bull-bats, and whip-poor-wills; swifts; humming birds; flycatchers; bobolinks,³ meadowlarks, and orioles; grosbeaks; tanagers; martins and other swallows; waxwings; shrikes; vireos; warblers; pipits; catbirds and brown thrashers; wrens; brown creepers; nuthatches; chickadees and titmice; kinglets and gnatcatchers; robins and other thrushes; and all other perching birds which feed entirely or chiefly on insects; and also auks, auklets, bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, and terns.

In some States certain days of the week constitute rest days or close seasons during the time when killing is permitted. Hunting on Sunday is prohibited in all States and Provinces east of the one hundred and fifth meridian, except Illinois, Louisiana, Michigan, Texas, Wisconsin, and Quebec. Mondays constitute a close season for waterfowl locally in Maryland and North Carolina; and certain other week days for waterfowl in several favorite ducking grounds in Maryland, Virginia, and North Carolina. Hunting is prohibited on election day in Maryland in Allegany, Baltimore, Cecil, Charles, Frederick, and Harford Counties; and when snow is on the ground in New Jersey, Delaware, Virginia, and Maryland.

The county laws of North Carolina are too numerous to be incorporated in the following summary, which otherwise may be regarded as a practically complete résumé of game regulations now in force.

The migratory-bird treaty-act regulations permit the possession of migratory game birds during the open season and the first 10 days following the close of the season. This provision has been considered in connection with State laws, and when migratory game birds may be legally possessed under Federal regulations and State laws during any part of the close season, it has been stated under the heading "Bag limits and possession." Possession of nonmigratory game during the close season is generally prohibited by State laws, but when an extension of a few days, or a special season, is provided for either possession or sale, attention is called thereto.

Under the heading "Interstate transportation," in addition to statements of restrictions on removal of game from the State in which it is taken, has been included information concerning the importation and possession by sportsmen for personal use of game legally killed outside the State and legally exported from the place where taken. In the absence of specific State legislation to the con-

² The full text of the migratory-bird treaty act and regulations and of Canadian and other regulations affecting birds and game will be found in a separate publication of the department (Service and Regulatory Announcement, B. S. No. 62).

³ See order of the Secretary permitting bobolinks, or reedbirds, to be killed in a few States for the protection of rice crops in the South, page 35.

trary, or where legislation prohibits possession of game in close season, it has been construed that sportsmen may bring home their game and possess it in their State in the same manner as though it had been killed there. The Federal regulations permit not to exceed 2 days' limit of migratory game birds to be transported in one calendar week from one State to another and allow such birds to be possessed in the State into which they are transported during the period constituting the open season where killed and for an additional period of 10 days next succeeding such open season, when such transportation and possession are not prohibited by State laws. Migratory game birds coming from a country other than Canada may be possessed in the State into which they are brought only during the open season in that State and such additional time immediately following such open season as may be permitted by both Federal and State laws.

The Federal migratory-bird treaty act prohibits the sale of all migratory game birds throughout the United States (except birds taken for scientific or propagating purposes, and waterfowl raised on farms or preserves, under proper permit from the Secretary of Agriculture—see regulations 8 and 9).⁴

In stating the open season⁵ the plan has been followed, as in the past, of including the *first and last days thereof*. The difficulty of attaining absolute accuracy in a statement of the seasons is very great, but summaries have been submitted to the proper State or Provincial game commissioners for correction and approval, and the following are believed to be free from material errors. Species (including migratory game and nongame birds protected throughout each year by Federal regulation) on which the season is closed for a term of years or for an indefinite period are grouped under the term "No open season." Provisions of State laws prohibiting hunting at night, between sunset and sunrise, or during certain hours, are not included.

Sportsmen should obtain information from the Biological Survey or State game departments⁶ to inform themselves of the existence of game and bird refuges in areas in which they contemplate hunting, as the location of refuges and the restrictions regarding hunting thereon are not included in this bulletin.

Persons are advised to obtain from State game commissioners⁶ the full text of game laws in States where hunting is contemplated.

For laws concerning traffic in imported game and game raised in captivity under Federal and State licenses, see pages 36-38.

State Laws

ALABAMA

Open seasons:⁷

	Dates inclusive
Deer (male).....	Nov. 1-Dec. 31.
Squirrel (black, gray, fox).....	Nov. 1-Jan. 31. ⁸
Bear.....	Nov. 1-Feb. 28.
Quail (partridge).....	Nov. 20-Feb. 19.
Wild turkey gobbler.....	Dec. 1-Mar. 31.
Turtle dove.....	Oct. 16-Jan. 31.
Duck, goose, brant, black-bellied and golden plovers, Wilson snipe, yellowlegs, coot (mudhen), gallinule.....	Nov. 1-Jan. 31.
Woodcock.....	Nov. 1-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Elk (1925); ruffed grouse (pheasant), introduced pheasant, or other introduced game bird (1927); does, turkey hens, swans, wood duck, bismarck, sandhill and whooping cranes, grebes, gulls, herons, loons, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident or alien, \$25. Resident: State, \$3; county, \$1. Trapping (bears and other fur-bearing animals), \$15 for first trap and \$2.50 for each additional trap. Issued by probate judges, landlords, tenants, and members of

ALABAMA—Continued

families may hunt or trap on own land during open season without license. Written permission required for hunting or trapping on land of another.

Bag limits and possession: One buck a day or in possession, 5 a season; 1 turkey gobbler a day or in possession, 10 a season; 10 squirrels a day or in possession; 15 quail a day or in possession; 8 each of geese and brant a day, 25 of each in possession; 25 each of doves, ducks, Wilson snipe, and sora a day or in possession; 25 in all of rails (except sora), coots, and gallinules a day, 25 of each in possession; 6 woodcock a day, 25 in possession; 15 in all of plovers and yellowlegs a day, 25 of each in possession. Possession of migratory game birds permitted during first 10 days of close season; other game during first 5 days.

Interstate transportation: Export of all protected game prohibited, except that a nonresident licensee may take with him, openly, game he has lawfully killed, but not more than 2 days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

⁴ See footnote 2, page 4.

⁵ For open seasons on fur-bearing animals for the season, 1924-25, see Farmers' Bulletin 1445.

⁶ See list on page 11 (back of title page). A full list of names and addresses of officials and organizations concerned with the protection of birds and game will be found in Dept. Circ. No. 328, U. S. Dept. Agr., 1924.

⁷ Alabama: Hunting prohibited on all State lands.

⁸ Squirrels may be killed at any time on own premises when destroying property.

ALASKA

Open seasons:¹

Dates inclusive

Bull moose, caribou, sheep
(rams only, south of Arctic
Circle) (see exceptions)..... Aug. 20-Dec. 31.

Exceptions:

Moose, south of latitude
62° and west of
longitude 146°..... Sept. 1-Dec. 31.

Sheep on Kenai Pen-
insula, east of longi-
tude 150°, July 1,
1926.

Deer with horns 3 inches long
(southeastern Alaska) (see
exception)..... Sept. 16-Dec. 15.

Exception:

Deer in southeastern
Alaska, west of longi-
tude 141°, 1926.

Mountain goat (except Kenai
Peninsula, east of longitude
150° and on Baranof and
Chichagof Islands, July 1,
1926)..... Aug. 20-Oct. 31.

Brown bear (north of latitude
62°, no close season)..... Oct. 1-July 1.

Grouse, ptarmigan..... Sept. 1-Mar. 1.

Duck, goose, brant, Wilson
snipe, black-bellied and
golden plovers, yellowlegs,
coot, gallinule..... Sept. 1-Dec. 15.

No open season: Females and young of deer and
mountain sheep, mountain goat kids, and fawns
of caribou, south of Arctic Circle; swans, wood
duck, eider ducks, auklets, cranes, fulmars,
grebes, guillemots, gulls, herons, jaegers, loons,
murrets, petrels, puffins, shearwaters, terns, and
all shorebirds (except Wilson snipe or jacksnipe,
black-bellied and golden plovers, and yellowlegs).

Unimak Island: Sportsmen should take notice
that Unimak Island is a part of the Aleutian
Islands Reservation and that hunting there is
illegal.

Hunting licenses: Nonresident, \$50;¹⁰ nonresident
alien, \$100;¹⁰ Guide, first class, \$25 (American
citizen); second class, \$7.50 (native of Alaska—
fee fixed by Secretary of Agriculture).

Shipping licenses: Resident, \$40 (export of
heads or trophies); \$10 (single trophy of caribou
or sheep); \$5 (single trophy of deer, goat, or brown
bear). Special license for shipping one moose
killed south of latitude 62°, \$150.

(Not more than one general (\$40) license and
two special (\$150) moose licenses issued to one
person in one year. Each shipper must file with
the customs office at port of shipment an affida-
vit that he has not violated the game law; that
the trophy to be shipped has not been purchased,
has not been sold, and is not shipped for purpose
of sale; that he is the owner of the trophy, and,
in case of moose, whether the animal from which
it was taken was killed north or south of latitude
62°.)

Hunting and shipping licenses issued by
chief Alaska game warden, Juneau.

Territorial licenses required of residents to
possess or transport trophies: Moose, \$10; caribou,
sheep, and goat, \$5 each; deer, \$2.50; brown and
grizzly bears, \$1 each. Issued by Territorial
treasurer and officers designated by him.

Bag limits and possession: It is unlawful for any
person in any one year to kill more than 2 moose
(1 moose south of latitude 62°), 3 deer, 3 caribou,
3 sheep, 3 goats, or 3 brown bears; or to kill or
have in possession in one day more than 25 grouse
or ptarmigan; or to kill more than 25 ducks, 8
geese, or 8 brant or have more than 25 in all com-
bined in possession in one day; or to kill more
than 15 in the aggregate of black-bellied and
golden plovers and yellowlegs, or more than 25
Wilson snipe or have more than 25 shorebirds in
the aggregate of all kinds in possession in one
day; or to kill more than 25 in the aggregate of
coots and gallinules in any one day. Ducks,
geese, brant, coot, gallinules, and shorebirds
may be possessed only during the open season
and the first 10 days of the close season. Other
game may be possessed for noncommercial pur-
poses at any time

ALASKA—Continued

Interstate transportation: Export prohibited of
deer, moose, caribou, sheep, goat, bear, or hides
of these animals; wild birds, except eagles, or
any parts thereof; provided, specimens may be
exported under restrictions imposed by the Sec-
retary of Agriculture, and trophies of big game
under licenses issued by the Chief Alaska Game
Warden, Juneau. (See Licenses.)

Game taken outside of Territory and legally
exported may be possessed at any time, except
that migratory game birds may be possessed
only during open season where taken and first
10 days of close season.

Sale: Sale of migratory birds and the hides, heads,
and skins of all protected game prohibited at all
times; sale of deer meat prohibited; unlawful also
to serve deer meat in any boarding house, cafe,
cannery, eating house, hotel, mess house, or
restaurant in Alaska or on board any steamer or
other vessel in the waters of Alaska; sale pro-
hibited of the meat, carcasses, or parts thereof,
of moose, caribou, sheep, or goat south of the
Chugach or Coast Range Mountains, including
Alaska Peninsula, Kenai Peninsula, and east to
longitude 141°, in any boarding house, cafe, can-
nery, eating house, hotel, mess house, restaurant,
or dining car. No meat, carcass, or parts thereof,
of moose, caribou, sheep, or goat shall be shipped,
or accepted for shipment, from any point on Kenai
or Alaska Peninsula unless accompanied by affi-
davit of owner that it was not purchased and is
not intended for sale.

Permitted: Carcasses of all game (except migra-
tory birds, and except deer, moose, caribou, and
sheep as above stated) may be sold during the
open season and, by dealers, during first 15 days
thereafter.

⁹ *Alaska:* All hunting prohibited on Kruzof and
Partofshikof Islands and in drainage of Taku
River east of line from Taku Point to east end of
the face of Taku Glacier until July 1, 1926. Game
animals or birds may be killed at any time in
Alaska for food or clothing by native Indians or
Eskimos, or by miners or explorers in need of
food, but game so killed may not be shipped or sold.

¹⁰ Not required for hunting deer or goats.

ARIZONA

Open seasons:¹¹

Dates inclusive

Deer (male), wild turkey..... Oct. 1-Nov. 1.

Quail (except bobwhite)..... Oct. 15-Dec. 31.

Mourning dove..... Sept. 1-Dec. 15.

White-winged dove..... July 15-Dec. 31.

Duck, goose, brant, Wilson
snipe, coot, gallinule..... Oct. 16-Jan. 31.

Black-bellied and golden plo-
vers, yellowlegs..... Oct. 15-Dec. 15.

Rail, other than coot and galli-
nule..... Oct. 15-Nov. 30.

No open season: Does, spotted fawns, elk, antelope,
sheep, goat, peccary or javelina (wild hog), bob-
white, grouse, pheasant, swans, bitterns, little
brown and sandhill cranes, grebes, gulls, herons,
loons, band-tailed pigeons, terns, and all shore-
birds (except Wilson snipe or jacksnipe, black-
bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident or alien:
Game and fish, \$20; birds (except turkeys) and
fish, \$10. Not issued to applicant under 12 years
of age. Resident: Game and fish, \$1.25. Issued
by game warden, designated deputies, and clerk
board of supervisors.

American-born resident under 17 years of age
may hunt without license, if accompanied by
holder of a general license.

Bag limits and possession: One deer, 2 turkeys a
season; 20 ducks, 8 geese, 20 coots, 15 plovers and
yellowlegs, and 20 rails, but not more than 20 in
all of waterfowl, plovers, yellowlegs, rails, and
coots a day or in possession; 25 quail, and 25
doves and white wings a day or in possession; 25
Wilson snipe a day. Possession of plovers, yel-
lowlegs, rails, and mourning doves permitted
during first 10 days of close season; other game
during first five days thereof.

ARIZONA—Continued

Interstate transportation: Export of all protected game prohibited.

Possession of game prohibited without a hunting license. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

Arizona: Animals or birds (except migratory birds) which become seriously injurious to agriculture or other interests may be killed under regulations of the State game warden.

ARKANSAS

Open seasons:

Male deer, turkey gobblers (gobblers also March 1-May 1) (see exceptions).....

Dates inclusive

Nov. 10-Jan. 15.

Exceptions: In Poinsett

County..... Nov. 10-Dec. 1.

In Faulkner, Perry,

Nov. 10, 1928.

In Chicot, Desha, and

Phillips Counties

(15 days), Nov.

15-19, Dec. 26-30,

and Jan. 10-14, in-

clusive; gobblers,

additional season,

March 1-May 1.

Bear in Chicot, Desha, and

Phillips Counties (15 days),

Nov. 15-19, Dec. 26-30, and

Jan. 10-14, inclusive.

Squirrel (see exceptions).....

May 15-Jan. 15.

Exceptions: In Chicot,

Desha, and Phillips

Counties.....

May 15-Dec. 31.

In Faulkner and

White Counties.....

July 1-Jan. 1,

In Lonoke County.....

June 15-Dec. 15.

Grouse (except prairie chicken

and pheasant).....

Dec. 15-Jan. 15.

Quail or partridge (see excep-

tions).....

Dec. 20-Feb. 28.

Exceptions: In Baxter,

Boone, Faulkner, and

White Counties.....

Dec. 20-Feb. 1.

In Chicot, Columbia,

Desha, and Phillips

Counties.....

Dec. 1-Mar. 1.

In Charleston Dis-

trict, Franklin

County.....

No open season.

Duck, goose, Wilson snipe,

coot, gallinule.....

Nov. 1-Jan. 31.

Woodcock (except in Faulkner

and White Counties, no open

season).....

Nov. 1-Dec. 31.

Black-bellied and golden plo-

vers, yellowlegs, dove.....

Sept. 1-Dec. 15.

Rail, other than coot and

gallinule.....

Sept. 1-Nov. 30.

No open season: Does, fawns, and wild turkey hens; bear (except as above), prairie chicken, pheasant (1928); swans, wood duck, bitterns, sandhill and whooping cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game, \$25; fish, general, \$5; special 15-day (trip), \$1.10; resident for deer, bear, and turkey, \$1.10; fish, \$1.10. For dog in hunting, \$1.50. Issued by State game and fish commission and circuit clerks. Citizen may hunt or fish during open season on own premises without a license. Hunting prohibited on inclosed lands without consent of owner. Scott County: Nonresident, game \$25; fish, \$25; issued by circuit clerk.

County licenses: Chicot County: Nonresident of State \$50; resident of State: All game, \$5.25; game (except deer, bear, and turkey), \$2.25. Dog (for deer or quail hunting), \$1.10. Desha County: Nonresident of State, \$50; resident of State: All

ARKANSAS—Continued

game, \$2.50; game (except deer, bear, and turkey), \$1.10. Dog (for deer or quail hunting), \$1. Phillips County: Nonresident of State, \$50; resident of State: All game, \$2.50; game (except deer, bear, and turkey), \$1.10. Dog (for deer or quail hunting), \$1. Scott County: Nonresident, game, \$25; fish, \$25. Issued by circuit clerk. License not required of resident under 16 in Chicot, Desha, and Phillips Counties.

Bag limits and possession: Two deer, 1 bear, 4 turkeys a season; 15 squirrels, 20 quail (40 in possession); 5 grouse; 25 doves; 25 ducks (50 in possession); 8 geese, 8 brant, 25 Wilson snipe, 6 woodcock, 15 in all of plovers and yellowlegs, 25 in all of rails, coots, and gallinules a day or in possession. Possession of game permitted during first 10 days of close season.

Local bag limits: In Arkansas County, 15 ducks a day or in possession; in Jackson County, 10 squirrels a day or in possession; in Chicot, Desha, and Phillips Counties, 10 squirrels a day.

Interstate transportation: Export of all game prohibited; provided, a nonresident, under his license and affidavit that game was legally taken by himself and is not for sale, may take with him one day's bag limit.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game; provided, squirrels may be sold except in Chicot, Desha, Jackson, and Phillips Counties.

CALIFORNIA¹³

Open seasons:

Dates inclusive

Male deer (except spike bucks),

in districts 1, 14, 44, 23, 24,

25, and 26.....

Sept. 1-Oct. 15.

In districts 2, 24, and 3.....

Aug. 1-Sept. 14.

In district 4.....

Sept. 16-Oct. 15.

Bear (black, brown),

Cottontail and brush rabbits,¹³

mountain, valley, and desert

quail (see exceptions).....

Nov. 1-Jan. 15.

Exceptions: Mountain and

valley quail, district 14.....

Oct. 15-Dec. 15.

Grouse.....

Sept. 15-Oct. 14.

Sage hen (except in district 44,

no open season).....

Aug. 1-Sept. 15.

Dove.....

Sept. 1-Oct. 31.

Duck, goose, brant, Wilson

snipe or jacksnipe, coot

(mudhen), gallinule.....

Oct. 1-Jan. 15.

No open season: Doe, spike buck, fawn, elk, antelope, sheep; tree squirrel (1925); pheasant, introduced quail or partridge, turkey, rail, plovers, yellowlegs, swans, wood duck, elder ducks, auklets, bitterns, little brown and sandhill cranes, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, band-tailed pigeons, puffins, shearwaters, terns, and all shorebirds (except Wilson snipe or jacksnipe).

Hunting and fishing licenses: Game: Nonresident, \$10; alien, \$25 (except those with first papers, fee \$10); fish; nonresident or alien, \$3. Resident: Game, \$1; fish, \$1. Fishing license not required of person under 18 years of age. Veterans of Civil War, issued free of charge. Issued by commissioners and county clerks. Unlawful to hunt in inclosure of another without permission of owner.

Bag limits and possession: Two deer a season; 15 cottontail or brush rabbits a day, 30 a week; 4 grouse a day, 8 a week; 4 sage hens a day, 8 a week; 10 mountain quail a day, 20 a week; 15 valley or desert quail a day, 30 a week; 25 Wilson snipe or jacksnipe a day, 50 a week; 15 mourning doves a day, 30 a week; 25 ducks a day, 50 a week; 8 geese (honkers) a day, 24 a week; 8 brant a day, 24 a week; 25 coots (mudhens) and gallinules a day, 50 coots a week.

Possession in excess of daily limit prohibited. Persons killing deer must retain in possession during open season and 10 days thereafter the skin and the portion of head bearing horns. One day's limit of game birds or animals may be possessed during first five days of close season.

CALIFORNIA—Continued

Interstate transportation: Export of all protected game prohibited. All shipment by parcel post prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of deer meat and hides, tree squirrels, and all game birds prohibited. Hides of deer taken in a foreign country and cottontail and brush rabbits taken during open season may be sold.

¹¹ *California:* Of the 59 fish and game districts created under the act of 1917, as amended in 1919 and 1921, 7 (1, 13, 2, 23, 3, 4, and 43) are properly hunting districts; 23, 24, 25, and 26 are fishing districts but are open to hunting; of the other 48 districts 26 are game refuges and 22 are fishing districts.

District 1 comprises the northern part of the State, the Sierras, and the east half of the Sacramento and San Joaquin Valleys, including all counties not included in districts 13, 2, 23, 3, 4, and 43.

District 13 comprises the counties of Del Norte, Siskiyou, and Humboldt.

District 2 comprises that part of the State south of Humboldt and Tehama Counties, west of the Sacramento River and north of San Francisco Bay, including the counties of Glenn, Colusa, Yolo, Solano, Napa, Lake, Sonoma, and Marin, and that portion of Mendocino County not included in district 24.

District 24 comprises that portion of Mendocino County lying west of divide between Eel and Russian River systems and Pacific Ocean and not included in District 7.

District 3 comprises the region around the southern portion of San Francisco Bay and the east counties south of the Golden Gate as far as Ventura, including the counties of Contra Costa, Alameda, Santa Clara, San Francisco, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, and Ventura; also San Benito and the western half of San Joaquin, Stanislaus, Merced, Fresno, and Kern Counties.

District 4 comprises the counties in southern California, namely, Los Angeles, Orange, Riverside, San Diego, Imperial, and San Bernardino.

District 43 comprises the counties of Mono and Inyo.

Districts 23, 24, 25, and 26, all located in district No. 1, are as follows:

District 23 comprises the drainage area of Lake Tahoe and the Truckee River in the counties of Placer and Eldorado.

District 24 comprises the drainage area of Silver, Twin, Blue, Meadow, and Wood Lakes in the counties of Alpine and Amador.

District 25 comprises the drainage area of Lake Almanor in the counties of Plumas and Lassen.

District 26 comprises Sixty Lake Basin, part of Rae Lake, and to the south fork of Woods Creek in Fresno County.

¹² Owner or tenant, or person holding written permission from owner or tenant, may kill rabbits on own premises at any time, but rabbits killed in close season may not be shipped or sold.

COLORADO

Open seasons: Dates inclusive

Deer (having horns with two or more prongs on each horn)	Oct. 12-Oct. 15.
Rabbit, hare	Unprotected.
Prairie chicken, mountain and willow grouse	Sept. 15-Oct. 1.
Duck, goose, brant, coot, gallinule, Wilson snipe or jack-snipe, black-bellied and golden plovers, yellowlegs	Sept. 16-Dec. 31.
Sora and other rail (except coot and gallinule)	Sept. 1-Nov. 30.

No open season: Elk, antelope, sheep, does, fawns, abert, black or tufted-eared squirrel, quail (bobwhite and crested), pheasant, dove (1930); sage chicken (1926); doe, partridge, ptarmigan, wild turkey, swans, wood duck, elder ducks, bitterns,

COLORADO—Continued

little brown, sandhill, and whooping cranes, grebes, gulls, herons, jacks, loons, band-tailed pigeon, terns, and all shorebirds (except Wilson snipe or jack-snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Big game, \$25; small game, \$5; fish, \$3. Resident: Big game, \$5; small game and fish, \$2. No person under 18 permitted to hunt big game. Fishing license not required of boys under 16 or of women. Children under 12 not permitted to hunt except on own premises or those of parent or guardian. Guide, \$5. Issued by commissioner, county clerks, and other agents. Unlawful to hunt in any inclosure not public land without consent of owner. Unlawful to shoot game from public highway.

Unnaturalized foreign-born residents not permitted to hunt or to own or possess shotgun, rifle, or pistol.

Bag limits and possession: One deer a season, coupon required; prairie chicken, 8 a day or in possession; mountain and willow grouse, 3 in all a day or in possession; 10 ducks, 8 geese, 8 brant, 15 Wilson snipe, 25 sora, 15 in all of other rails, coots, and gallinules, 10 in all of plover and yellow legs a day or in possession. Persons under 12 years of age limited to half this number of birds. Possession permitted during first 5 days of close season. Commissioner may issue permit authorizing storage, possession, and use of game for 90 days after close of open season (except possession of migratory birds limited to 10 days after close of season).

Interstate transportation: Export of all protected game is prohibited; provided, birds, not exceeding the numbers allowed in possession, may be exported under permit from game commissioner (fee 25 cents for each bird) if permit be attached and packages plainly marked so as to show nature of contents, but not more than 2 days' limit of migratory birds shall be exported in any one calendar week; edible portion of deer may be exported under \$5 permit from the commissioner.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Importer must secure from State game and fish commissioner a certificate, fee \$1, to import game.

Sale: Sale of all game taken in State prohibited, but game (except migratory birds) coming from without State may be sold under license by indorsement of shipping invoice to purchaser.

CONNECTICUT

Open seasons: Dates inclusive

Deer ¹⁶	
Hare, rabbit (except Belgian or German hare and jack rabbit, unprotected)	Nov. 1-Dec. 15.
Gray squirrel, ruffed grouse, pheasant, male only, woodcock	Oct. 8-Nov. 23.
Duck, goose, brant	Oct. 1-Jan. 15.
Coot (mudhen), gallinule	Oct. 1-Dec. 31.
Black-bellied and golden plovers, yellowlegs	Sept. 1-Nov. 30.
Wilson or English snipe	Oct. 1-Nov. 30.
Rail, other than coot and gallinule	Sept. 12-Nov. 30.

No open season: Quail, Hungarian partridge (Oct. 8, 1925); pheasant hen, dove, swans, wood duck, elder ducks, auks, bitterns, fulmars, gannet, grebes, guillemots, gulls, herons, jacks, loons, murrets, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jack-snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: \$10.25. Resident citizen, \$1.25. Not issued to persons under 16. Issued by city or borough clerk. Resident and his children may hunt during open season without a license on land on which he is actually domiciled if land is not used for club or

CONNECTICUT—Continued

Hunting and fishing licenses—Continued

shooting purposes. Alien not permitted to hunt. Licensee must report amount of game killed. Fishing license, required of males over 16 years of age: Nonresident, \$2.25; resident, \$1.25. Resident and his children may fish during open season without a license in waters on land on which he is actually domiciled, if such land or waters are not used for club or fishing purposes.

Bag limits and possession: Five gray squirrels a day, 30 a season; 3 rabbits a day, 30 a season; 5 woodcock a day, 36 a season; 3 ruffed grouse a day, 21 a season; 2 pheasants a day, 15 a season; 25 ducks, 8 geese, 8 brant a day; 10 in all of plover, yellowlegs, and Wilson snipe; 35 sora and 25 in all of other rails, coot, and gallinules a day. Possession of more than daily bag limit of game prima facie evidence of violation. Resident may possess during first 10 days of close season, for his own use and not for sale, game lawfully taken.

Interstate transportation: Export of all protected game prohibited; provided, a licensee under permit may export game lawfully killed and possessed, when tagged to show name, address, and license number of shipper, if not for sale; but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Importer must secure from superintendent of fisheries and game a permit to import game.

Sale: Sale of all protected game prohibited.

¹⁴ *Connecticut:* Governor may suspend open seasons during time of drought.

¹⁵ Owners of agricultural lands, member of family, or employee may kill deer with a shotgun at any time on such lands when deer are damaging fruit trees or growing crops, but such killing or wounding must be reported to the commissioners within 12 hours.

DELAWARE

Open seasons: ¹⁶ Dates inclusive

Rabbit, hare, quail, partridge	Nov. 15-Dec. 31
Squirrel (fox, black, gray)....	Sept. 1-Oct. 15.
Dove (except in Newcastle County, no open season)....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 1-Dec. 31.
Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule.....	Oct. 16-Jan. 31.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Reedbird (see Order, p. 35)....	Sept. 1-Oct. 30.

No open season: Hungarian partridge or pheasant, swans, wood duck, eider ducks, bitterns, sandhill cranes, grebes, gulls, herons, loons, murres, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game, \$10.50; fish, \$3.50 (not good in Delaware River or Bay). Resident: Game and fish, \$1.10 (required outside county of residence). Issued by commissioner. Resident landowner may hunt or fish during open season on own land without license. Unlawful to hunt on land of another without permission from owner or occupant. Fishing license not required of certain excursionists. Nonresidents who own or lease property at seaside summer resorts and their relatives, friends, and patrons sojourning at such resorts may fish for nongame fish and hunt without license during open season, between June 1 and September 30.

Bag limits and possession: Six in all of rabbits, hares, and squirrels, 20 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 6 woodcock, 50 sora, 25 in all of other rails, coots, and gallinules, but not more than 50 in all of sora and other rails combined; 12 birds of any other species (except reedbirds) a day. Possession of migratory birds permitted during first 10 days of close season; other game during first 5 days thereof.

DELAWARE—Continued

Interstate transportation: Export of rabbit, squirrel, quail, partridge, dove, woodcock, goose, and brant is prohibited; provided holder of license may export, open to view, 10 rabbits, 10 squirrels, 50 rails, and 20 birds or fowl of any other species a week, lawfully killed by himself, under affidavit that the game is not for sale. Resident may export ducks, snipe, and plover. In no event, however, may a person export more than 2 days' limit of migratory birds in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of reedbirds and all protected game prohibited; provided, a resident may sell in his own county 20 rabbits a season, lawfully taken by him. Rabbits coming from without the State may be sold from November 15 to December 31.

¹⁶ *Delaware:* Minors under 15 years of age not permitted to hunt game with shotgun or rifle unless accompanied by an adult lawfully hunting.

DISTRICT OF COLUMBIA ¹⁷

Open seasons: Dates inclusive

Deer meat (sale or possession).....	Sept. 1-Jan. 1.
Rabbit (except English rabbit, Belgian hare), squirrel (sale or possession).....	Nov. 1-Feb. 1.
Marsh blackbird.....	Sept. 1-Feb. 1.
Duck, goose, brant, Wilson snipe, coot, gallinule.....	Nov. 1-Jan. 31.
Black-bellied and golden plovers, yellowlegs.....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 1-Dec. 31.
Rail, ortolan.....	Sept. 1-Nov. 30.
Reedbird (see Order, p. 35)....	Sept. 1-Oct. 30.

No open season: Dove, swans, wood duck, bitterns, grebes, gulls, herons, loons, murres, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Bag limits and possession: Twenty-five ducks, 8 geese, 8 brant, 25 Wilson snipe, 6 woodcock, 50 sora, 25 in all of other rails, coots, and gallinules, 15 in all of plovers and yellowlegs a day. Possession of migratory birds permitted during first 10 days of close season; quail, November 1 to March 15; ruffed grouse or pheasant (except English or other imported pheasants raised in inclosures, possession unrestricted) and wild turkey, November 1 to December 28; prairie chicken (pinnated grouse), September 1 to March 15.

Interstate transportation: Export of migratory game birds in excess of two days' bag limit in any one calendar week prohibited.

Migratory game birds taken outside of District and legally exported may be possessed during open season where taken and first 10 days of close season. Other game may be possessed during open season in District.

Sale: Sale of all game birds prohibited. Deer, rabbit, and squirrel may be sold during open season.

¹⁷ *District of Columbia:* Hunting prohibited in the District by act of June 30, 1906, except on the marshes of the Eastern Branch above Anacostia Bridge and below the Aqueduct Bridge on the Virginia side of the Potomac, but in these areas no birds may be shot within 200 yards of any bridge or dwelling.

FLORIDA

Open seasons: Dates inclusive

Deer, squirrel (see exceptions), quail (bobwhite partridge), wild turkey.....	Nov. 20-Feb. 15.
Exception: Squirrels in Escambia County.....	Oct. 15-Mar. 1.
Squirrels in Holmes and Walton Counties.....	Oct. 20-Mar. 1.
Ruffed grouse, imported pheasants (see exception)....	Nov. 20-Dec. 19.
Exception: English pheasant in Escambia County, no open season.	

FLORIDA—Continued

Open seasons—Continued		Dates inclusive
Duck, goose, brant, black-bellied and golden plovers, Wilson snipe, yellowlegs, coot, gallinule, dove.....	Nov. 20-Jan. 31.	
Woodcock.....	Nov. 1-Dec. 31.	
Rail, other than coot and gallinule.....	Nov. 20-Nov. 30.	
Reedbird (ricebird) (see Order p. 35).....	Aug. 16-Nov. 15.	
No open season: All wild birds and animals (except opossum and skunk) protected on Pine Island, Lee County. Swans, wood duck, bitterns, sandhill and whooping cranes, gannet, grebes, gulls, herons, jaegers, loons, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).		
Hunting licenses: Nonresident or alien (county license), \$25; resident, \$1.25 (county of residence); resident, \$3.50 (county other than county of residence). License not required in voting precinct nor of Confederate veteran entitled to a State pension. Issued by county judge.		
Bag limits and possession: Two deer, 5 turkeys, and 300 of any other game birds a year; 1 deer, 2 turkeys, 20 quail, 25 ducks, 8 geese, 8 brant, 25 Wilson snipe, 6 woodcock, 25 in all of rails, coots, and gallinules, 15 in all of plovers and yellowlegs, and 25 doves a day. Camping or hunting party of 3 or more limited to 2 deer and 3 turkeys. Possession of migratory birds permitted during first 10 days of close season; other game during first 5 days thereof.		
Interstate transportation: Export of all protected game is prohibited, except that nonresident licensee may carry out game as personal baggage, but not more than two days' limit of migratory game birds may be exported in any one calendar week.		
Game taken outside of State and legally exported may be possessed in like manner as game taken in State.		
Sale: The sale of reedbirds (ricebirds) and all protected game is prohibited.		

GEORGIA

(Laws of 1924 not received)

Open seasons:		Dates inclusive
Deer.....	Nov. 1-Dec. 31.	
Rabbit, fox squirrel.....	Unprotected.	
Cat squirrel.....	Oct. 1-Feb. 28.	
Opossum.....	Oct. 1-Feb. 1.	
Quail (except in Douglas County, no open season), partridge, wild turkey gobblers.....	Nov. 20-Feb. 28.	
Duck, goose, brant, coot, gallinule.....	Nov. 1-Jan. 31.	
Black-bellied and golden plovers, yellowlegs, Wilson snipe, dove.....	Nov. 20-Jan. 31.	
Woodcock.....	Nov. 1-Dec. 31.	
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.	
Reedbird (ricebird). (See Order, p. 35).....	Aug. 16-Nov. 15.	
No open season: Fawn, grouse, pheasant, turkey hen, introduced game birds, swans, wood duck, elder ducks, bitterns, sandhill and whooping cranes, gannet, grebes, gulls, herons, loons, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers and yellowlegs).		
Hunting licenses: Nonresident, \$15; resident, State, \$3; county, \$1 (good only in county of residence). License not required in militia district or to hunt on own or leased land. Issued by commissioner or county warden.		
Bag limits and possession: Two deer, 2 turkeys a season; 15 cat squirrels, 25 quail, 25 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 6 woodcock, 25 in all of rails, coot, and gallinules, 25 doves a day. Possession of		

GEORGIA—Continued

migratory birds except woodcock permitted during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited; provided, nonresident licensee may take out in personal possession game lawfully killed, but not more than 2 days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be imported under a permit, fee \$1 and possessed under a permit, fee \$1, in like manner as game taken in State. Permits issued by game and fish commissioner.

Sale: Sale of reedbirds (ricebirds) and all protected game prohibited.

HAWAII

Open seasons:		Dates inclusive
Deer.....	Apr. 1-Oct. 31.	
Pheasant (male), quail.....	Nov. 1-Jan. 31.	
Wild dove, wild pigeon.....	July 1-Dec. 31.	
Native wild duck.....	Nov. 1-Jan. 31.	
No open season: Wild geese, hen pheasants, skylarks; wild goat, sheep, cattle, pigs.		
Hunting licenses: Aliens and nonresident citizens (county license), fee \$25; resident citizen, \$5. Permission of owner or occupant required to hunt on lands of another.		
Bag limits and possession: Cock pheasant, 5; other birds, 25 a day; possession of deer meat prohibited during closed season.		

IDAHO

Open seasons:		Dates inclusive
Elk in Bingham, Bonneville, Clark, Fremont, and Teton Counties.....	Nov. 1-Nov. 30.	
Elk in Clearwater and Idaho Counties.....	Oct. 1-Nov. 15.	
Mountain goat in Custer and Lemhi Counties.....	Oct. 1-Nov. 15.	
Deer, mountain goat in Adams, Blaine, Boise, Bonneville, Butte, Clark, Elmore, Gooding, Jefferson, Lincoln, Madison, Power, Teton, and Valley Counties.....	Oct. 15-Nov. 15.	
Deer in Clearwater, Custer, Idaho, Latah, Lemhi, Lewis, and Nez Perce Counties.....	Oct. 1-Nov. 15.	
In Benewah, Bonner, Boundary, Kootenai, and Shoshone Counties.....	Nov. 1-Nov. 30.	
In Franklin County.....	Oct. 15-Nov. 1.	
Bear.....	Unprotected.	
Quail in Ada, Gem, Gooding, Kootenai, Nez Perce, and Owyhee Counties.....	Nov. 1-Nov. 15.	
Sage hen (see exceptions).....	Aug. 1-Aug. 31. ¹²	
Exceptions: In Bear Lake and Caribou Counties.....	Aug. 16-Aug. 31	
In Ada, Adams, Blaine, Boise, Camas, Canyon, Cassia, Elmore, Franklin, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Payette, Twin Falls, Valley, and Washington Counties.....	No open season.	
Chinese, ring-necked, or Mongolian pheasants in Ada, Canyon, Gem, Gooding, Jerome, Latah, Lincoln, Nez Perce, Owyhee, Payette, Twin Falls, and Washington Counties.....	Nov. 1-Nov. 30.	
In Bingham County.....	Nov. 1-Nov. 15.	
Grouse in Benewah, Bonner, Boundary, Kootenai, and Shoshone Counties.....	Oct. 1-Oct. 31.	
In Clearwater, Idaho, Latah, Lewis, and Nez Perce Counties.....	Sept. 15-Oct. 15.	

IDAHO—Continued

Open seasons—Continued	Dates inclusive
Blue or dusky grouse in Bannock, Bingham, Bonneville, Butte, Clark, Fremont, Idaho, Lemhi, Madison, and Teton Counties.	Sept. 15-Oct. 15.
In Bear Lake, Caribou, Franklin, and Oneida ¹⁰ Counties.	Sept. 1-Oct. 1.
Ruffed grouse in Bannock, Bear Lake, Bingham, Bonneville, Butte, Caribou, Clark, Custer, Franklin, Fremont, Jefferson, Madison, Oneida, ¹⁰ Power ¹⁰ and Teton Counties.	Sept. 15-Oct. 15.
Dove.	Sept. 1-Dec. 15.
Duck, goose, brant, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs, coot, and gallinule.	Sept. 16-Dec. 31.
Rail, other than coot and gallinule.	Sept. 1-Nov. 30.

No open season: Deer, elk, mountain goat (except as above); moose, antelope, caribou, mountain sheep, buffalo, spotted fawn, calf elk; quail, grouse (except as above), imported pheasants (except Chinese ring-necked, and Mongolian pheasants as above); prairie chicken, swans, wood duck, bitterns, little brown and sandhill cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: ²⁰ Game and fish, \$25; bird, \$5; fish, \$3. Alien: Game and fish, \$50; fish, \$10; gun license, \$5. Resident: Game and fish, \$2. Issued by warden, deputy, or authorized agent. Fishing license not required of minor under 14 years of age or of resident women, and veterans of Civil War may hunt and fish without a license. Persons under 12 prohibited from possessing gun afield.

Bag limits and possession: One deer, 1 elk, 1 goat a season; 8 quail; 4 in all of Chinese ring-necked and Mongolian pheasants; 6 in all of sage hen, native pheasant, and grouse a day or in possession; 25 doves, 25 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 50 sora and 25 in all of other rails, coots, and gallinules a day. Migratory waterfowl may be stored by owner, under affidavit and storage permit, during open season and 10 days thereafter. Game may not be shipped, transported, or carried more than 5 days after close of open season.

Interstate transportation: Export of all protected game prohibited; provided, a hunter may export one day's limit of game birds and, under hunting-license coupon, big game lawfully taken; big game once shipped within State may be exported under a 50-cent permit obtained from game warden or deputy. Mounted heads and stuffed birds legally secured may be exported under a reshipping permit. Shipment of game by parcel post prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited. Hides, heads, and horns may be sold under permit.

¹⁰ Idaho: State game warden may close season in any county or part thereof on any species of game or fish which is threatened with extinction.

²⁰ No open season for sage hens and grouse in that portion of Minidoka National Forest, Sublette Division, in Power and Oneida Counties.

²¹ Residents of adjoining States having larger nonresident license fee for big game hunting must pay fee charged in own State.

ILLINOIS

Open seasons: ²¹	Dates inclusive
Rabbit, in Southern and Central Zones.	Nov. 10-Jan. 1.
In Northern Zone.	Nov. 10-Jan. 31.
Squirrel, in Northern Zone.	Sept. 1-Dec. 1.
In Central Zone.	Aug. 1-Dec. 1.
In Southern Zone.	July 1-Dec. 1.
Quail (bobwhite).	Nov. 10-Dec. 10.
Prairie chicken.	Nov. 10-Nov. 21.
Introduced pheasant (cocks).	Nov. 10-Nov. 15.
Dove.	Sept. 1-Sept. 30.
Duck (except wood duck), goose, brant, Wilson snipe, coot, gallinule, black-bellied and golden plovers, yellowlegs.	Sept. 16-Dec. 31.
Rail, other than coot and gallinule.	Sept. 16-Nov. 30.

No open season: Deer (1929); wild turkey, introduced pheasant hen, sand grouse, ruffed grouse (partridge), blue, mountain, and valley quail, Hungarian partridge, capercaillie, heath hen, black grouse, woodcock (1929); swans, wood duck, eider ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, murrelets, petrels, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses:²² Nonresident citizen, \$10.50; resident citizen, \$1. Licenses not issued to aliens, nor to minors under 16 without written consent of parent or guardian. Issued by village, county, or city clerk. Owners, their children, and tenants in actual residence may hunt during open season on own land without license. Permission required to hunt on lands of another. Taxidermist, \$5.

Bag limits and possession: Ten squirrels, 15 rabbits, 12 quail, 3 prairie chickens, 2 cock pheasants, 15 doves, 15 in all of black-bellied and golden plovers and yellowlegs, 15 snipe, 15 in all of coot and gallinules, 15 rail, but not more than 25 in all of rails, coots, and gallinules, 15 ducks, 8 geese, 8 brant a day. Limit, in possession, 20 squirrels, 36 quail, 12 prairie chickens, 6 cock pheasants, 25 doves, 50 black-bellied and golden plovers and yellowlegs, 50 snipe, 60 coots and gallinules, 60 rail, 60 ducks, 10 geese, 10 brant.

Interstate transportation: Export of all protected game (except rabbit) prohibited; provided, nonresident licensee may take from State 50 game birds or animals, if carried openly for inspection, but not more than 2 days' limit of migratory birds may be exported in any one calendar week. Resident may carry out game under his license.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game (except rabbit during open season) prohibited.

²¹ Illinois: Southern Zone includes Madison, Bond, Fayette, Effingham, Jasper, Crawford, and all counties south. Central Zone includes Hancock, McDonough, Fulton, Tazewell, McLean, Ford, and all counties south to northern boundary of Southern Zone. Northern Zone includes rest of counties of State.

²² Angling licenses: Resident, \$0.50; nonresident, \$1.25. Issued by county, city, and village clerks. Not required of person under 21.

INDIANA

Open seasons:	Dates inclusive
Rabbit.	Apr. 1-Jan. 9.
Squirrel.	Aug. 1-Nov. 30.
Quail, ruffed grouse.	Nov. 10-Dec. 20.
Prairie chicken.	Oct. 15-Nov. 1.
Duck, goose, brant.	Sept. 16-Dec. 31.
Woodcock.	Oct. 1-Nov. 30.

INDIANA—Continued

Open seasons—Continued *Dates inclusive*
 Black-bellied and golden plovers, yellowlegs, Wilson snipe or jacksnipe, coot, gallinule Sept. 16–Dec. 20.
 Rail, other than coot and gallinule..... Sept. 1–Nov. 30.

No open season: Deer, Hungarian partridge, introduced pheasant, wild turkey, dove, swans, woodcock, bitterns, sandhill and whooping cranes, gannet, grebes, gulls, herons, jaegers, loons, murrets, petrels, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game and fish, \$15.50; fish, \$1. Resident: Game and fish, \$1. Issued by clerk circuit court. Not issued to person under 14 without written consent of parent or guardian. Honorably discharged soldiers, sailors, and marines, and those in the regular service who are resident of the State require no license to hunt and fish; owners of farm land, their children living with them, and tenants may hunt during open season on own land without a license. No license required of persons to fish in county of residence or contiguous counties. All children under 18 and wife of licensee may fish without license. Permission required to hunt on lands of another.

Bag limits and possession: Fifteen quail, 5 prairie chickens, 15 ducks, 8 geese, 8 brant a day; 45 quail, 45 ducks, 24 geese, 24 brant, in possession as result of 3 or more days' consecutive hunting; 25 Wilson snipe, 6 woodcock, 50 sora, and 25 in all of other rails, coots, and gallinules, and 15 in all of plovers and yellowlegs a day. Possession of waterfowl permitted during first 10 days of close season.

Interstate transportation: Export of deer, quail, grouse, prairie chicken, pheasant, wild turkey, woodcock, duck, goose, brant, and other waterfowl prohibited, except that nonresident may take from State 15 birds, killed by himself (or 45 if he has hunted for 3 or more days consecutively) if carried openly for inspection together with license, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Deer, turkeys, and rabbits taken outside of State and legally exported may be possessed at any time; other game legally exported may be possessed in like manner as game taken in State.

Sale: Sale of quail, prairie chicken, introduced pheasants, Hungarian partridges, and migratory birds prohibited.

Miscellaneous: Shooting on highways or with searchlight prohibited.

IOWA

Open seasons: *Dates inclusive*
 Squirrel (gray, timber, or fox) Sept. 1–Jan. 1.
 Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule, black-bellied and golden plovers, yellowlegs..... Sept. 16–Dec. 31.
 Woodcock..... Oct. 1–Nov. 30.
 Rail, other than coot and gallinule..... Sept. 16–Nov. 30.

No open season: Deer, elk; quail, prairie chicken, introduced pheasants, Hungarian partridge (1927); ruffed grouse or pheasant, wild turkey (1932); turtle dove, swans, wood duck, elder ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, murrets, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident or alien, game, \$10; nonresident, fish, \$3 (required of males over 18 years of age). Resident citizen, \$1. Issued by county auditor. License not granted to persons under 18 without written consent of parent or guardian. Owners of farm lands, their children, and tenants, may hunt on own lands during open season without license. Unlawful to hunt on cultivated or inclosed lands of another without permission from owner.

IOWA—Continued

Bag limits and possession: Fifteen ducks, 8 geese, 8 brant, a day, 50 waterfowl in possession; 15 in all of plovers and yellowlegs, 5 Wilson snipe, 6 woodcock, 5 each of rails, coots, and gallinules a day, but not more than 25 in all of rails, coots, and gallinules a day; 5 of each species in possession. Possession permitted during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited, except that nonresident may take from State not more than 25 game birds or animals, if carried openly for inspection, and if hunting license be shown on request, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. After expiration of first 10 days of close season in State, possessor of game must show lawful taking.

Sale: Sale of all protected game prohibited.

KANSAS

Open seasons: *Dates inclusive*
 Fox squirrel..... Aug. 1–Jan. 1.
 Quail (season closed in odd, open in even years)..... Dec. 1–Dec. 10.
 Prairie chicken..... Sept. 20–Sept. 30.
 Dove..... Sept. 1–Oct. 15.
 Duck, goose, brant, Wilson snipe, coot, gallinule, black-bellied and golden plovers, yellowlegs..... Sept. 16–Dec. 31.
 Rail, other than coot and gallinule..... Sept. 1–Nov. 30.

No open season: Deer, antelope (1925); red, gray, and black squirrels, ruffed grouse (partridge), pheasant (English, Mongolian, Hungarian); woodcock, swans, wood duck, elder ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$15. Issued by secretary of state. Resident, \$1. Issued by county clerk. Resident landowner or member of family may hunt on own land during open season without a license. Unlawful to hunt on land of another or on highway or railroad right of way adjacent thereto without consent of owner, unless accompanied by him. Alien not permitted to hunt.

Bag limits and possession: Quail, 10 a day, 50 a season; 25 in all of ducks, coots, and gallinules; 20 doves, 5 prairie chickens, 5 in all of geese and brant, 6 rails, and 15 in all of Wilson snipe, plovers, and yellowlegs a day. Possession permitted during first 5 days of close season.

Interstate transportation: Export of all protected game birds prohibited, except that a person may carry or transport open to view, and in his personal possession, not more than 2 days' limit of 2 kinds of game, legally taken by himself.

Game of not more than two kinds, and not more than two days' bag limit, taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. After expiration of first 5 days of close season in State, possessor of game must show lawful taking.

Sale: Sale of all protected game birds prohibited.

KENTUCKY

Open seasons: *Dates inclusive*
 Rabbit¹..... Nov. 15–Dec. 31.
 Squirrel..... July 1–Dec. 15.
 Quail, ruffed grouse (native pheasant)..... Nov. 15–Jan. 1.
 Dove..... Sept. 1–Dec. 15.
 Woodcock..... Nov. 15–Nov. 30.

KENTUCKY—Continued

Open seasons—Continued	Dates inclusive
Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule, black-bellied and golden plovers, yellowlegs, rail, other than coot and gallinule	Sept. 16-Dec. 31.
No open season: Deer, elk (1928); introduced pheasants, Hungarian partridge, wild turkey (1928); swans, wood duck, bitterns, sandhill and whooping cranes, grebes, gulls, herons, jaegers, loons, petrels, terns, and all shorebirds (except woodcock, Wilson snipe, black-bellied and golden plovers, and yellowlegs).	Sept. 1-Nov. 30.
Hunting licenses: Nonresident or alien, \$7.50. Resident, \$1. Issued by county clerk. Resident landowner, tenant, and members of families may hunt on own land during open season without license. Unlawful to enter inclosed lands of another for shooting, hunting, or fishing without consent.	
Bag limits and possession: Twelve quail a day, 15 in possession for each successive day of hunt; 15 doves a day, 15 in possession for each successive day of hunt; 2 ruffed grouse a day; 25 ducks, 8 geese, 8 brant, 6 woodcock, 15 in all of plovers and yellowlegs, 25 Wilson snipe, and 25 in all of other rails, coot, and gallinules a day.	
Interstate transportation: Export of deer, elk, and all game birds prohibited, except that a hunter may transport game lawfully killed and possessed by him, but not more than 2 days' limit of migratory birds may be exported in any one calendar week.	
Game taken outside of State and legally exported may be possessed during open season in State in like manner as game taken in State.	
Sale: Sale of quail, partridge, grouse, introduced or native pheasant, Hungarian partridge, wild turkey, and migratory birds, wherever killed, prohibited.	

²¹ Kentucky: Rabbits may be taken with dogs or traps (except snares) at any time for a person's own use on his own land, but not for sale or barter.

LOUISIANA

Open seasons:	Dates inclusive
Deer, ²² bear, ²³ squirrel, chipmunk, hare, rabbit, dove	Nov. 15-Jan. 31.
Quail	Dec. 1-Feb. 15.
Wild turkey	Dec. 1-Jan. 31.
Gros-bee (night heron)	July 1-Nov. 1.
Duck, goose, brant, black-bellied and golden plovers, Wilson snipe, yellowlegs, rail, coot, gallinule	Nov. 1-Jan. 31.
No open season: Fawns, elk, prairie chicken, introduced pheasant, upland plover (papabotte) (1928); swans, wood duck, woodcock, bittern, sandhill and whooping cranes, gannet, grebes, gulls, herons, loons, petrels, terns, and all shorebirds (except Wilson snipe or jacksnipe, blackbellied and golden plovers, and yellowlegs).	
Hunting licenses: Nonresident or alien: Deer and bear, \$50; other game, \$25; resident, \$1. Issued by tax collectors. Nonresident or alien not permitted to hunt for profit. License does not authorize hunting on land of another without his written consent.	
Bag limits and possession: Two deer a day or in possession, 5 a season; 15 squirrels and chipmunks, 15 quail, 1 turkey, 25 doves, 25 ducks, 8 geese, 8 brant, 10 in all; 25 in all of rails, coots, and gallinules; 15 gros-bee; 15 in all of plovers, and yellowlegs; 25 Wilson snipe and 15 other birds in all a day. Possession permitted during first five days of close season.	
Interstate transportation: Export of all protected game prohibited; provided a nonresident licensee may carry with him out of the State under his license two days' limit of game, if not for sale; the head, hide, feet, or fur of wild quadrupeds, and plumage or skin of birds legally taken may be exported if contained in a package properly marked. All game and all packages containing game must be tagged to show kind and number, names of consignor and consignee, initial point	

LOUISIANA—Continued

of billing, and destination. Bears may not be exported, except under written permission of conservation department.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. After expiration of first 5 days of close season in State, possessor of game must show lawful taking.

Sale: Sale of all game (except squirrels and rabbits during open season) prohibited.

²⁴ Louisiana: Deer season fixed by conservation commissioner.

²⁵ Nonresidents coming into State to hunt bears must report in writing to conservation department before arrival at destination.

MAINE

Open seasons:	Dates inclusive
Deer (see exception)	Oct. 16-Nov. 30.
Exception: In Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, Waldo, and York Counties	Nov. 1-Nov. 30.
Hare, rabbit	Oct. 1-Feb. 28.
Gray squirrel	Oct. 1-Oct. 31. ²⁶
Ruffed grouse, partridge, woodcock	Oct. 1-Nov. 30.
Duck, goose, brant, Wilson snipe, coot, gallinule (see exception)	Sept. 16-Dec. 31.
Exception: Waterfowl, in Back Bay, Portland, above Grand Trunk railway bridge	No open season.
Black-bellied and golden plovers, yellowlegs (see exception)	Aug. 16-Nov. 30.
Exception: In Merrymeeting Bay and towns adjacent thereto	Sept. 16-Nov. 30.
Rail, other than coot and gallinule	Sept. 1-Nov. 30.
No open season: Moose (1928); deer on Cross, Scotch, Swan, and Mount Desert Islands, and in towns of Deer Isle, and Stonington, in Hancock County, in Isle au Haut, in Knox County, in Perkins, Sagadahoc County, Kineo Point and Katahdin Park Game Preserve, Piscataquis County, Ganeston Park and Augusta Game Preserve, Kennebec County, Rangeley Game Preserve, Franklin and Oxford Counties, Lincoln County Game Preserve, and in all places where hunting is prohibited by law; cow and calf, moose, caribou, quail, Hungarian partridge, pheasant, black game, capercaillie, cock of the woods, dove, swans, wood duck, eider ducks, auks, bitterns, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).	
Hunting and fishing licenses: Nonresident hunting licenses: Deer or other game (except caribou and moose), October 16-December 31, \$15; birds, prior to October 16 in Aroostook, Franklin, Hancock, Oxford, Penobscot, Piscataquis, Somerset, and Washington Counties, \$5; season (except November) in rest of State (8 southern counties), \$5. For November (in southern counties), a \$15 license is required. Holder of a license may exchange it for a license for which a larger fee is required by paying the difference in cost. Nonresident must be accompanied by registered guide when hunting or when camping and kindling fires while fishing on wild lands (and in unorganized or unincorporated townships), May 1 to November 30. Nonresident fishing license, \$3.15 (not required of children under 16 years of age); resident alien fishing license, \$2.15. Resident alien, game, \$15 (not required of aliens who pay taxes on real estate and who have resided in State two years continuously prior to application). Taxidermist: Resident citizen, \$5; resident alien, \$25. Guide licenses: Nonresident, \$20 (issued only	

MAINE—Continued

Hunting and fishing licenses—Continued

to residents of adjoining States or Provinces); resident, \$1. Must not guide more than five persons hunting at one time. Sporting camp, \$5. Shipping licenses (within State): Resident, deer, \$2; one pair of game birds in seven days, 50 cents. Issued by commissioner.

Resident hunting and fishing license, fee 25 cents. Resident or member of immediate family may hunt during open season on own land used exclusively for agricultural purposes and on which he is actually domiciled without a license. License valid as long as holder remains citizen of State. Issued by city, town, and plantation clerks.

Bag limits and possession: Two deer (except in Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, Waldo, and York Counties, collectively, limit 1) a season; 5 ruffed grouse a day, 25 a season; 10 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs but not more than 5 plovers, 10 Wilson snipe, 6 woodcock, and 25 in all of rails, coot, and gallinules a day. Transportation of migratory game birds must be completed within five days after close of season; reasonable time allowed after close of season to transport other game to home of owner. Deer may not be used or had in possession in lumber camps. Possession of migratory birds limited to first 10 days of close season; deer legally secured may be possessed during close season.

Interstate transportation: Export of all protected game prohibited; provided, a resident of the State, under shipping license (fee, \$5) may export 5 partridges, 6 woodcock, or 10 ducks, lawfully killed by himself, but he must accompany the birds. A nonresident may export, open to view under hunting-license tags, 2 deer, 5 partridges, 10 ducks, and 6 woodcock, lawfully killed by himself, upon identifying same at shipping point; nonresident licensee may also ship out one pair of game birds a month under a special 50-cent license.

Moose or caribou, or parts thereof, taken outside of State and legally exported may be imported under permit and shipping tag and possessed at any time. Deer properly tagged where taken and game birds may be imported under permit during open season in State and possessed in like manner as game killed in State, but not more than 2 deer may be killed anywhere and possessed in State during one season. Permits and shipping tags issued by commissioner of inland fisheries and game.

Sale: Sale of all protected game birds prohibited; unlawful to sell or give away deer for export. Local provision dealer, under \$5 license, may purchase 2 deer for retail to his customers. Deer skins and skins with heads attached may be bought and sold by residents under \$25 license. Heads when detached from skins with which purchased may be sold to licensed taxidermists.

Miscellaneous: Unlawful to possess rifle or shotgun, either loaded or with a cartridge in the magazine thereof, in or on any motor vehicle while upon any highway or in the fields or forest.

³⁹ *Maine:* Commissioner may make local regulations and governor may suspend hunting or fishing seasons during drought.

³⁷ All hunting is prohibited on Kineo Point and Mount Katahdin, Piscataquis County; on Prouts Neck, and on Richmonds Island, Cumberland County; southern point Swan Island; and locally in town of Eden, Hancock County, Cape Elizabeth, and town of Scarborough, Cumberland County. (See State laws for details and other protected areas).

³⁸ Squirrels protected in parks and in compact or built-up portions of cities and villages.

MARYLAND

Open seasons:

Deer (male—having an antler .6 or more inches in length without points) in Allegany County and within game preserves inclosed with 7-foot fence in Washington County.....

Dates inclusive

Dec. 1-Dec. 15.

Rabbit, quail (partridge), ruffed grouse (pheasant), wild turkey (see exception),

Nov. 10-Jan. 1.

Exception: Wild turkey in Garrett County.....

Nov. 10-Dec. 24.

Squirrel³⁹.....

Sept. 1-Oct. 15.

Woodcock.....

Nov. 10-Dec. 31.

Dove.....

Sept. 1-Dec. 15.

Duck, goose, brant, Wilson snipe, coot, gallinule.....

Nov. 1-Jan. 31.³⁰

Black-bellied and golden plovers, yellowlegs.....

Aug. 16-Nov. 30.³⁰

Rail, other than coot and gallinule.....

Sept. 1-Nov. 1.

Reedbird (see Order, p. 35).....

Sept. 1-Oct. 30.

No open season: Deer, elk (1928); introduced pheasant, swans, wood duck, elder ducks, auks, bitterns, sandhill crane, gannet, grebes, gulls, herons, jaegers, loons, murrets, petrels, shearwaters, terns, and all shorebirds (except woodcock Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$10.50 (fee \$5.10 for State license if applicant owns real estate in Maryland assessed at \$500; \$1.10 for county license in county where such real estate is located); resident, State, \$5.10; county, \$1.10; issued by clerks of circuit court—in Baltimore City by clerk, court of common pleas. License not issued to person under 14 years of age without written request of parent or guardian. Licensee required to wear tag displayed on middle of back. Owners, tenants, and their children may hunt on own land during open season without license. Patuxent River Club license, \$25; issued by clerk of circuit court.

Sinkbox, sneak boat, blind, pusher.—*Cecil:* Sneak boat (Bohemia and Elk Rivers), \$5.50; sinkbox (Bohemia and Elk Rivers), \$10.50 (see also Sassafras River). *Anne Arundel:* Pusher, \$2; booby and brush blinds (west side Chesapeake Bay), \$5; (South River), \$2.50. *Harford:* Sinkbox, \$20.75; sneak boat, \$5.75. *Kent:* In waters from Fairlee Creek to north end of Hickory Thicket, blind, \$5 (see also Sassafras River). *Comerys:* Bight: Sinkbox, \$20.50; blind, \$5.50. *Queen Anne:* Sinkbox, \$10.50; booby blind, \$5.50. *Susquehanna Flats:* Sinkbox, \$20.75; sneak boat, \$5.75. *Talbot:* Sinkbox or blind, \$5 (issued to county resident only). *Patuxent River:* Pusher, \$2.50 (required of residents to push or paddle nonresidents); blind, \$5.25 (required in Calvert County, south of Hunting Creek). *Sassafras River:* Sinkbox, blind, \$10.50 (issued only to residents of Kent and Cecil Counties or owners of real estate therein assessed at \$500).

Bag limits and possession: One deer, 4 wild turkeys a season; 10 rabbits, 25 squirrels, 12 quail (partridge), 2 ruffed grouse, 6 woodcock, 25 doves, 25 jacksnipe, 15 yellowlegs, 5 black-bellied plover, 15 golden plover (but not more than 15 plover, and yellowlegs combined), 50 reedbirds, 50 sora, 25 in all of other rails, coots, and gallinules (but not more than 50 sora and other rails combined), 25 waterfowl (but not more than 8 geese and 8 brant) a day for each licensed gunner (not exceeding 4) connected with an outfit. Possession of waterfowl, Wilson snipe, and plovers permitted during first 10 days of close season, and of doves until December 24.

Interstate transportation: Export of all protected game (except waterfowl) prohibited; provided,

MARYLAND—Continued

Interstate transportation—Continued

a licensed hunter may take out under his license an amount equal to one day's bag limit of game, if not for sale; provided, further, no person may take out more than 50 ducks, 16 geese, and 16 brant in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of quail, ruffed grouse, wild turkey, introduced pheasant, and doves, reedbirds, and all other migratory game birds is prohibited.

²⁰ **Maryland:** Owner or tenant may shoot squirrel on own land Sept. 1 to Jan. 1.

²⁰ Wild-fowl shooting restricted locally as follows: On the Susquehanna Flats north of a line extending from Turkey Point Lighthouse, Cecil County, and half a mile north of Spesutia Island to Oakington, Harford County, hunting allowed only on Mondays, Wednesdays, and Fridays, Nov. 1-Jan. 1, and Mondays, Wednesdays, Fridays, and Saturdays, Jan. 1-Jan. 31; in Harford County only before 2 p. m.; in Anne Arundel County, on Magothy River on Tuesdays, Thursdays, and Saturdays; on Rhode and West Rivers on Mondays, Wednesdays, and Fridays; in Calvert County, on Patuxent River south of Hunting Creek and on Severn River on Mondays, Wednesdays, and Saturdays; in Cecil County, on Bohemia and Elk Rivers on Mondays, Wednesdays, Fridays, and Saturdays; in Dorchester County, on Choptank River on Tuesdays, Thursdays, and Saturdays; in Kent County, on Chester River and tributaries, on Mondays and Fridays only, Nov. 1 to Jan. 24, except that in Comegys Bight shooting is permitted from sink-boxes and blinds on Mondays, Wednesdays, and Saturdays, Nov. 1 to Jan. 31, in St. Marys County, on Wicomico River and tributaries on Tuesdays, Thursdays, and Saturdays.

MASSACHUSETTS

Open seasons: ²¹**Dates inclusive**

Deer (from sunrise, first Monday in December to sunset the following Saturday, inclusive).....

Dec. 1-Dec. 6.

Hare (known as varying or Canada hare or snowshoe or white rabbit) or rabbit (see exception).....

Oct. 20-Feb. 28.

Exception: European hares in Berkshire County, unprotected.

Gray squirrel, quail, ruffed grouse, pheasant (male),²² woodcock (see exception).....

Oct. 20-Nov. 20.

Exception: Quail in Dukes, Essex, Hampden, Hampshire, Middlesex, Nantucket, Norfolk, and Worcester Counties (1925).

Duck, goose, brant, Wilson snipe, gallinule.....

Sept. 16-Dec. 31.

Black-bellied and golden plovers, yellowlegs.....

Aug. 16-Nov. 30.

Rail, other than coot and gallinule.....

Sept. 1-Nov. 30.

No open seasons: Moose, dove, prairie chicken, Hungarian partridge, pheasants (English, golden Mongolian),²³ heath hens, swans, wood duck, eider ducks, auks, bitterns, sandhill and whooping cranes, fulmars, gannet, guillemots, gulls, herons, jaegers, loons, murrets, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident citizen: General, \$10; fish, \$2. Members of incorporated game clubs owning real estate assessed at not less than \$500 for each member, and which were organized prior to 1907; owners or their minor children over 18 years old, of real estate assessed at not less than \$500; or nonresidents invited (for not more than four days) by members of incorporated

MASSACHUSETTS—Continued

club for hunting foxes, pay a fee of \$1.50. Resident citizens: General, \$2; hunt and trap, \$1.50; fish, \$1. License not issued to minors under 15, and those under 18 years of age must apply in writing and furnish written consent of parent or guardian. A license (fee, 25 cents) to trap quadrupeds, in discretion of issuing officer, may be issued to any minor between the ages of 12 and 18, who is a citizen. Resident may hunt during open season on own land used exclusively for agricultural purposes and on which he is actually domiciled, and minors under 18 may fish, without a license. Alien: General, \$15; fish, \$2 (applicant must own real estate to the assessed value of \$500 to secure a hunting license but fishing license may be issued to applicant who has taken out first naturalization papers). Issued by city or town clerks.

Bag limits and possession: One deer a season; 2 hares and 5 rabbits a day or in possession; 5 gray squirrels a day, 15 a season; 4 quail a day, 20 a season; 3 ruffed grouse a day, 15 a season; 2 pheasants a day, 6 a season; 4 woodcock a day, 20 a season; 25 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 50 sora, and 25 in all of other rails, coots, and gallinules (but not more than 25 in all of Wilson snipe, coots, and gallinules or more than 25 in all of coots, gallinules, and rails other than sora) a day. Resident may possess deer during first 30 days and other game during first 10 days of closed season if legally taken or acquired by him, and for his personal use only and not for sale; game legally taken and exported from another State or country may be imported and possessed for 10 days after arrival. Under permit from director, resident may bring into State not more than 50 migratory game birds.

Interstate transportation: Export of quail, woodcock, and ruffed grouse taken in State prohibited; provided a nonresident under his license may take 10 birds into another State according similar privilege, if carried open to view and the commission or district deputy is notified; provided further, a resident may export all game (except quail, ruffed grouse, woodcock), but not more than two days' bag limit of migratory birds may be exported in any one calendar week. No game illegally taken may be exported.

Game taken outside of State and legally exported may be possessed for personal use as follows: Migratory game birds, during open season where taken and first 10 days of close season; other game, during open season and, if imported during close season, deer may be possessed 30 days and other game 10 days immediately succeeding arrival in State.

Sale: Sale of all game prohibited; provided, deer, moose, caribou, and elk lawfully killed and coming from without State, under warden's tag, may be sold under license at any time. Hares or rabbits lawfully secured and coming from a State where their sale is not prohibited may be sold during the open season.

Miscellaneous: Deer may be taken with a shotgun. Unlawful to hunt or kill game with rifle or revolver during open season for deer, or to have dog in the woods, except in Dukes and Nantucket Counties.

²¹ **Massachusetts:** Governor may suspend open seasons during extreme drought.

²² Commission may open season on pheasants.

²³ License required to fish in inland waters which have been stocked with fish by the commission since Jan. 1, 1910.

MICHIGAN

Open seasons: ²⁴**Dates inclusive**

Deer (male, with horns not less than 3 inches above the skull).....

Nov. 10-Nov. 30.

Rabbit, hare (see exception).....

Oct. 15-Jan. 31.

Exception: Snowshoe or jack rabbit.....

Oct. 15-Feb. 15.

Squirrel (fox).....

Oct. 15-Oct. 31.

MICHIGAN—Continued

Open seasons—Continued	Dates inclusive
Ruffed grouse, partridge (see exception), woodcock.....	Oct. 15–Nov. 20.
Exception: Ruffed grouse, Upper Peninsula.....	Oct. 15–Nov. 9.
Duck, goose, brant, Wilson snipe, coot, gallinule, black-bellied and golden plovers, yellowlegs.....	Sept. 16–Dec. 31.
Rail, other than coot and gallinule.....	Sept. 16–Nov. 30.
No open season: Elk, moose, caribou, European partridge, dove, quail, squirrel (except fox squirrel), introduced pheasants, Hungarian partridge, black game, capercaillie, hazel grouse, Canada or spruce grouse, prairie chickens, wild turkey (1926), swans, wood duck, elder ducks, auks, bitterns, sandhill and whooping cranes, gannet, grebes, gulls, herons, jaegers, loons, murres, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).	

Hunting and fishing licenses: Nonresident: Deer, \$50; small game, \$10; fish, general, \$5; special (fish, except brook trout and bass), \$2 (fishing license not required of person under 18 years of age). Resident: Deer, \$2.50; small game, \$1. Issued by county clerks, director, or deputy. Licenses issued to persons under 17 and over 12 on application of parent or guardian, who must accompany such minor when hunting. Residents and minor children may hunt during open season small game on own inclosed land on which they reside without a license.

Bag limits and possession: One deer a season; 5 fox squirrels a day or in possession, 15 a season; 7 rabbits a day, 10 in possession, 25 a season; 5 partridges a day, 10 in possession, 25 a season; 25 ducks a day, 50 in possession, 50 a calendar week; 6 geese and brant a day or in possession, 25 a season; 6 woodcock a day, 20 in possession, 25 a season; 15 Wilson snipe a day, 25 a season; 15 in all of black-bellied and golden plovers and yellowlegs a day, 25 in possession, 25 each a season; 50 snipe and 25 in all of other rails, coots, and gallinules a day. Game birds lawfully killed may be possessed during first 10 days of close season, and game animals during first 30 days thereof. Camping party of six or not less than four licensed hunters maintaining a camp of not less than four persons for not less than seven days may, under permit (fee \$3), kill one deer for camp purposes.

Interstate transportation: Export prohibited of all protected game. *Exceptions:* (1) Deer may be transported outside the State to reach a point within the State. (2) Nonresident licensee may take out, as hand baggage, open to view, one day's bag limit of birds, and may ship one deer lawfully killed by himself when license tag and seal are attached. (3) Deer skins and green or mounted buck-deer heads may be exported under permit.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game; provided, deer skins and green or mounted buck-deer heads lawfully taken may be sold or transported under permit.

¹⁴ *Michigan:* The director upon approval of the Conservation Commission may shorten or close the season and otherwise restrict the taking of any species of game (except that he may not modify open seasons on waterfowl as fixed by Federal or State law) for a period not to exceed five years, in any county upon petition of 25 or more citizens of such county, if, upon public hearing, it is determined that the species is threatened with depletion or extinction. Such orders may be modified or rescinded when conditions warrant.

MINNESOTA

Open seasons: ¹⁵	Dates inclusive
Deer (season closed in odd, open in even years).....	Nov. 10–Nov. 20.
Rabbit (see exception).....	Unprotected.
Exception: Varying hare, or snowshoe rabbit.....	Oct. 15–Mar. 1.

MINNESOTA—Continued

Open seasons—Continued	Dates inclusive
Black bear, squirrel (gray, black, or fox).....	Oct. 15–Jan. 1. ¹⁶
Quail.....	Oct. 15–Nov. 20.
Ruffed grouse or partridge (season closed in odd, open in even years).....	Oct. 15–Nov. 20.
Male ring-necked pheasant (season closed in odd, open in even years).....	Oct. 15–Oct. 18.
Prairie chicken or pinnated grouse, white-breasted or sharp-tailed grouse (season closed in even, open in odd years).....	Sept. 16, 1925.
Dove.....	Sept. 16–Oct. 1.
Woodcock.....	Oct. 1–Nov. 30.
Duck (except wood duck), goose, brant, coot, gallinule, Wilson snipe or jacksnipe, yellowlegs.....	Sept. 16–Dec. 31.
Rail, other than coot and gallinule.....	Sept. 16–Nov. 30.

No open season: Elk, moose, caribou, ring-necked pheasant, hen, upland plover, black-bellied and golden plovers, swans, wood duck, elder ducks, auks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, and yellowlegs).

Hunting and fishing licenses: Nonresident or alien: Big game, \$50.25 (includes metal locking seal); small game, \$15. Issued by commissioner. Fishing license, \$2 (not required of person under 16 years of age). Issued by commissioner, county auditors, game wardens, and agents. Resident: Big game animals, \$2.25 (includes metal locking seal); small game, \$1; fish house, \$1. Issued by county auditor. Not issued to person under 14 years of age. Owners, lessees, or members of their immediate families may hunt birds during open season on own or leased land occupied by them as permanent residence without license. Unlawful to enter growing grain fields for purpose of hunting without permission of owner.

Bag limits and possession: One deer a season; 5 geese, and 15 in all of ducks, coots, gallinules, Wilson snipe or jacksnipe, yellowlegs, and rails a day, 45 in all in possession, 135 ducks a season; 10 quail a day, 20 in possession, 30 a season; 6 woodcock, 9 doves, but not more than 9 in all of woodcock and doves a day, 30 in all a season; 3 ring-neck pheasants a day or in possession, 3 a season. Possession permitted during first five days of close season. Under permit or tags deer may be possessed to February 28, migratory birds for 10 days after close of season, and other game birds to January 31.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may ship home in open season under his license coupons 1 deer and 25 birds lawfully taken by himself, but not more than 16 geese or 12 woodcock may be exported in any one calendar week. Deer hides for tanning and heads for mounting may be exported when tagged with license coupons (deer season closed in odd years).

Game taken outside of State and legally exported may be possessed at any time under a retaining tag, obtained from State game and fish commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game (except varying hare) prohibited; provided, hides of deer legally killed may be sold.

Miscellaneous: Unlawful to carry gun in motor vehicle unless unloaded in both barrel and magazine and taken apart or contained in a case. Unlawful to keep game in cold storage.

¹⁵ *Minnesota:* All hunting prohibited within 3 miles of the corporate limits of Duluth, Minneapolis, and St. Paul.

¹⁶ *Squirrels* protected within corporate limits of any city or village, or within one-fourth mile thereof.

MISSISSIPPI

Open seasons: ³⁷	Dates inclusive
Deer (male), bear.....	Nov. 15-Mar. 1.
Rabbit, squirrel.....	Unprotected.
Quail or partridge.....	Nov. 1-Mar. 1.
Wild turkey gobblers.....	Jan. 1-May 1.
Dove.....	Oct. 16-Jan. 31.
Waterfowl, Wilson snipe or jacksnipe, coot, poule d'eau, gallinule, black-bellied and golden plovers, yellowlegs.....	Nov. 1-Jan. 31.
Woodcock.....	Nov. 1-Dec. 31.
Rail, other than coot and gal- linule.....	Sept. 1-Nov. 30.

No open season: Does; turkey hens, swans, wood duck, bitterns, sandhill crane, grebes, gulls, herons, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$20 (county license). Issued by sheriff. Landowners and their non-resident relatives and friends may hunt during open season on own lands without license.

Bag limits and possession: One deer a day, 5 a season; 20 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs; 25 Wilson snipe, 6 woodcock, 25 doves, 15 in all of rails, coots, and gallinules, but a mixed bag shall not exceed 20 birds. Possession of migratory birds permitted during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited.

Game taken outside of State and legally exported may be possessed only during open season in State, but migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited.

³⁷ *Mississippi:* Local regulations of boards of supervisors may also be in force, but those relating to migratory birds must not be inconsistent with Federal regulations. The game law enacted in 1922 does not become effective in any county until adopted by the board of supervisors. It is not known to what extent, if at all, the boards have adopted the act. For information, address sheriffs or county clerks at the county seat of each county. The provisions of the 1922 law are as follows:

Open seasons.—Deer (male), Nov. 15-Feb. 15; bear, Nov. 1-Feb. 28; hare, rabbit, unprotected; squirrel, Oct. 15-Feb. 1; quail or partridge, Nov. 15-Mar. 1; wild turkey gobblers, Jan. 1-May 1; dove, Sept. 16-Dec. 31; waterfowl, Wilson snipe or jacksnipe, coot, poule d'eau, gallinule, black-bellied and golden plovers, yellowlegs, Nov. 1-Jan. 31; woodcock, Nov. 1-Dec. 31; rail, other than coot and gallinule, Sept. 1-Nov. 30.

No open season.—Does, spotted fawns, turkey hens, introduced pheasant, western quail, ruffed grouse, swans, wood duck, bitterns, sandhill crane, grebes, gulls, herons, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses.—Nonresident (county license): All game, \$50; quail and squirrel, \$20; angling, \$2. Issued by sheriff. Hunting and angling license not required of minor under 16 years of age. Landowners and their nonresident relatives and friends may hunt without license during open season on own lands. The board of supervisors may require a local resident hunting license and fix the fee therefor.

Bag limits and possession.—One deer a day, 3 a season; 1 bear and 2 turkey gobblers a season; 15 squirrels, 20 quail, 25 ducks, 8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 6 woodcock, 25 doves, 50 sora and 25 in all of other rails, coots, and gallinules a day, but nonresident may not kill more than 25 in all of migratory game birds a day. Possession of game permitted during first 10 days of close season.

Sale.—Sale of all protected game prohibited.

Export.—Export of all protected game prohibited; provided, a nonresident may take out of the State 2 turkey gobblers, 20 quail, 25 ducks,

MISSOURI

Open seasons:	Dates inclusive
Deer (buck), wild turkey.....	Dec. 1-Dec. 31.
Squirrel.....	June 1-Dec. 31.
Quail (bobwhite partridge).....	Nov. 10-Dec. 31.
Duck, goose, brant, Wilson snipe, coot, gallinule, black- bellied and golden plovers, yellowlegs.....	Sept. 16-Dec. 31.
Woodcock.....	Nov. 10-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 15-Nov. 30.

No open season: Does, fawns under 1 year of age, ruffed grouse (pheasant), prairie chicken (pin-tailed grouse), imported pheasants, other introduced game birds, dove, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jacks, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident or alien: Game and fish: \$10; fish, \$3. Issued by commissioner. Resident: Game and fish: State, \$2.50; county, \$1, good in county of residence or adjoining county; fish (State), \$1. Issued by county clerk or license collector. Fishing license not required in county of residence nor of women or minors who are citizens. Owners and tenants of agricultural lands and members of family under 21 residing thereon may hunt without license during open season on own or leased land when used for agricultural purposes only, but may not transport or ship game or fur animals therefrom without a license. Hunting on land of another prohibited without his consent.

Bag limits and possession: One deer, 4 turkeys a season; 1 turkey, 10 quail, 15 ducks, 8 geese, 8 brant, 6 woodcock, 15 in all of plovers and yellowlegs, 15 Wilson snipe a day; 15 rails, 15 coots, 15 gallinules, but not more than 25 in all a day or in possession; or 2 turkeys, 15 quail, 25 of any other species of birds in possession. Possession of migratory birds permitted during first 10 days of close season; other game during first 5 days thereof.

State hunting license required to possess game. Interstate transportation: Export of all protected game prohibited, except that not more than two days' limit of game may be exported under resident or nonresident license if carried openly as baggage or express or in owner's possession and accompanied by him.

Game taken outside of State and legally exported may be possessed in like numbers and manner as game taken in State, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited.

MONTANA

Open seasons: ²⁸	Dates inclusive
Deer (male with horns 4 inches above the skull) (see excep- tions).....	Oct. 15-Nov. 15.
Exceptions: Deer, either sex, in Flathead, Lin- coln, Mineral, Ravalli, and Sanders Counties ..	Oct. 15-Nov. 15.
In Carter, Custer, Dawson, Garfield, Mc- Cone, Phillips, Powder River, Prairie, Rich- land, Roosevelt, Rose- bud, Stillwater, Teton, Valley, Yellowstone, and parts of Fergus, Gallatin, and Lewis and Clark Counties (1925).	

8 geese, 8 brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 6 woodcock, 25 doves, 50 sora, and 25 in all of other rails, coots, and gallinules.

Propagation.—Game raised in captivity under license may be sold by dealer or proprietor of hotel or restaurant under \$5 license.

MONTANA—Continued

Open seasons—Continued	Dates inclusive
Elk in Flathead, Glacier, Madison, Pondera, Sweet Grass, Teton, and parts of Gallatin, Missoula, and Powell Counties.....	Oct. 15–Nov. 15.
In part of Lewis and Clark County.....	Nov. 5–Nov. 15.
In Park County.....	Oct. 15–Dec. 20. ³⁹
Bear (unlawful to trap).....	No close season.
Pheasant, partridge, prairie chicken, fool hen, sage hen, grouse in State (except in Cascade County, no open season).....	Sept. 15–Sept. 24.
Duck, goose, brant, black-bellied and golden plovers, Wilson snipe or jacksnipe, yellowlegs, coot, gallinule.....	Sept. 16–Dec. 15.
Rail, other than coot and gallinule.....	Sept. 16–Nov. 30.
No open season: Sheep, goat (1926); elk (except as above), does and fawns, moose, caribou, antelope, bison, or buffalo; quail, introduced pheasant, Hungarian partridge, dove, swans, wood duck, bittern, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs.)	

Hunting and fishing licenses: Nonresident citizen: General, \$30; small game and fish, \$10; fish, \$3.50. Alien: General, \$50; fish, \$10. Resident citizen,⁴⁰ General, \$2.00. Guide (resident citizen), \$10. Shipping (export), 50 cents. Taxidermist, \$15. Issued by warden or deputy.

No license required of minor under 15. Alien not holding a hunting license required to obtain from warden \$25 license to possess firearms.

Bag limits and possession: One buck (1 deer of any age or either sex in Flathead, Lincoln, Mineral, Ravalli, and Sanders Counties), 1 elk a season; 5 in all of grouse, partridges, prairie chickens, fool hens, pheasants, and sage hens a day or in possession; 20 ducks, 8 in all of geese and brant, 15 in all of plovers and yellowlegs, 25 Wilson snipe, 25 in all of rails, coot, and gallinules a day. Waterfowl legally taken may be possessed until January 10 following close of open season.

Interstate transportation: Export of all protected game prohibited; provided, game lawfully killed may be exported in open season under hunting license, and shipping permit (fee, 50 cents) from State warden; total shipments under one license may not exceed season's bag limit, and not more than 2 days' limit of migratory birds may be exported in any one calendar week; packages must be labeled to show contents.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of bears and all protected game prohibited; provided, merchant or hotel or restaurant keeper may sell game, except migratory birds, killed outside the State. Under permit, mounted specimens or hides or heads of game animals or birds lawfully taken may be sold.

³⁹ Montana: Commission may close season in any district on any species of game threatened with undue depletion from any cause, or reopen such districts.

⁴⁰ Commission may on five days' notice close season on elk in Park County any time after November 15.

⁴¹ Resident licenses issued to officers of the Forest Service and of the Bureau of Biological Survey, U. S. Department of Agriculture, and to officers and soldiers of the U. S. Army.

NEBRASKA

Open seasons:	Dates inclusive
Squirrel (gray, red, fox, timber).....	Sept. 16–Dec. 31.
Prairie chicken, grouse.....	Oct. 1–Nov. 1.

NEBRASKA—Continued

Open seasons—Continued	Dates inclusive
Duck, goose, brant, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs, coot, gallinule.....	Sept. 16–Dec. 31.
Rail, other than coot and gallinule.....	Sept. 16–Nov. 30.

No open season: Deer, elk, antelope, mountain sheep, quail, partridge, sage hen, pheasant, ptarmigan, introduced game birds, dove, wild turkey, woodcock, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: General, \$10.10; fish, \$2.10. Alien: General, \$15.10; fish, \$5.10. Resident, \$1.10. Issued by State department of agriculture and authorized vendors. Licenses required of all persons over 16 years of age. Alien not permitted to hunt or to own or possess firearms.

Bag limits and possession: Ten squirrels a day, 20 in possession; 10 prairie chickens or grouse a day or in possession; 25 ducks a day, 50 in possession; 8 geese, 8 brant a day, 10 each in possession; 15 Wilson snipe a day, 25 in possession; 15 in all of plovers and yellowlegs a day, 25 in possession; 15 rails, 25 coots, but not more than 25 rails and coots a day, 25 rails and 50 coots in possession, 50 in all of game birds in possession. Possession permitted during first 10 days of close season.

Interstate transportation: Game may be transported by express or baggage during the open season if shipment is accompanied by shipper's affidavit that the game is not for sale or profit and was not taken contrary to law; package must be labeled with consignor's license number and kind of game, consigned to shipper, and accompanied by him; shipment must not contain more than 50 game birds or the possession bag limit on any species. Not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

NEVADA

Open seasons:	Dates inclusive
Deer (male with horns).....	Oct. 16–Oct. 21. ⁴¹
Bear.....	Nov. 15–Mar. 15.
Cottontail rabbit, mountain hare.....	Nov. 1–Dec. 31.
Grouse, mountain quail.....	Sept. 24–Sept. 30.
Sage hen or sage cock, prairie chicken.....	Aug. 16–Aug. 31.
Dove.....	Sept. 1–Dec. 15.
Duck, goose, brant, coot, gallinule, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs.....	Sept. 16–Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1–Nov. 30.

No open season: Elk, sheep, goat, antelope (1930); does, fawns; quail, pheasant; swans, wood duck, bitterns, little brown and sandhill cranes, grebes, gulls, herons, loons, murres, band-tailed pigeons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game, \$10; fish, \$3. Alien: Fish, \$7.50. Resident citizen: Game, \$1.50; fish, \$1.50. Hunting and fishing licenses issued free of charge to resident Indians. Issued by county clerks and wardens. Aliens prohibited from hunting. No license required of boys or girls under 14. Landowners may hunt and fish on own land without license during open season.

Bag limits and possession: One deer a season; 5 cottontail rabbits, 2 mountain hares, 10 valley quail, 5 mountain quail, 3 partridge, 3 grouse, 3 pheasants, 5 prairie chickens, 10 sage hens, 25

NEVADA—Continued

Bag limits and possession—Continued.

ducks, 5 geese, 5 brant, 10 snipe, and 25 doves a day or in possession; 15 in all of plovers and yellowlegs, 50 sora, and 25 in all of other rails, coots, and gallinules a day. Possession of migratory birds permitted during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of deer meat and of all other protected game prohibited.

⁴¹ Nevada: County commissioners may fix open seasons on pheasants and valley quail, and shorten open seasons on other game upon petition of 50 or more resident electors of county; and may designate open season of 15 days on buck deer between September 15 and November 15, instead of October 16 to October 21, or close season entirely.

⁴² Citizen of any State must pay same fee for hunting or fishing license as charged nonresidents by his State of residence.

NEW HAMPSHIRE

Open seasons: ⁴³	Dates inclusive
Deer in Coos County.....	Oct. 15-Nov. 30.
In Carroll County.....	Nov. 15-Dec. 15.
In Grafton County.....	Nov. 1-Dec. 15.
In rest of State.....	Dec. 1-Dec. 31.
Hare, rabbit.....	Oct. 1-Feb. 28.
Partridge, ruffed grouse, woodcock.....	Oct. 1-Nov. 30.
Pheasant (male) in Hillsborough, Rockingham, and Strafford Counties only.....	Nov. 1-Nov. 6.
Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule.....	Sept. 16-Dec. 31.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Elk, moose, caribou, dove, quail, pheasant, European partridge; gray squirrel (1924); swans, wood duck, elder ducks, auks, bitterns, sandhill crane, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game and fish, \$15; fish, \$2.15. Resident: Game and fish, \$1. Resident soldiers and sailors over 70 years of age may hunt and fish without a license. Fishing licenses not required of children under 16 years of age, nor of women or blind people. Issued by commissioner or his agent in each town, who with few exceptions is the town clerk. Licenses not granted to children under 13 years of age, and only with written consent of parent or guardian to minors under 16 years. Child under 16 may hunt without license when accompanied by licensed parent or guardian. Resident owner of farm lands and his minor children may hunt during open season on own land without license. Guide: Nonresident, \$20; resident, \$1. Issued by commissioner.

Bag limits and possession: Two deer a season in Coos and Carroll Counties, 1 in rest of State (person securing 1 deer in any of the one-deer counties may take 1 additional deer in Coos or Carroll County); 5 hares a day; 5 ruffed grouse a day, 25 a season; 6 woodcock a day, 25 a season; 20 ducks, 8 geese, 8 brant, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 50 sora, and 25 in all of other rails, coots, and gallinules a day. Deer may be possessed for a reasonable time after close of open season. Two pheasants a day, 6 a season.

Interstate transportation: Export of all protected game prohibited, provided, the head, hide, feet, or fur of game quadrupeds, and the plumage or skin of game birds (except migratory birds) legally taken and possessed may be transported without being marked. ⁴⁴ Nonresident may take

NEW HAMPSHIRE—Continued

out of the State, under his hunting license and permit, one day's limit of game birds when properly marked and tagged and two deer under, license tags.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all migratory birds prohibited. Sale for food purposes prohibited of the dead bodies of birds belonging to a family any species or subspecies of which is native to and protected by the State; provided, deer, hares, and rabbits may be sold during the open season.

⁴⁵ New Hampshire: Governor and council may suspend open season in time of excessive drought.

⁴⁶ Sec. 243, Lacey Act (see footnote 2, p. 4).

NEW JERSEY

Open seasons:	Dates inclusive
Deer ⁴⁵ (male, with horns visible above the hair).....	Dec. 17-Dec. 21.
Raccoon.....	Oct. 1-Dec. 15.
Rabbit, squirrel, quail (see exception), ruffed grouse (partridge), prairie chicken, English or ring-necked pheasant cocks (see exception).....	Nov. 10-Dec. 15.
Exceptions: Ring-necked pheasant in city of Trenton and township of Hamilton, Mercer County; in townships of Chesterfield, North Hanover, New Hanover, Pemberton, Woodland, Tabernacle, and Shamong, Burlington County; in townships of Waterford and Winslow, Camden County or within territory lying between said townships and Delaware River.....	
Quail in Bergen, Essex, Hudson, Hunterdon, Morris, Passaic, Somerset, Sussex, Union, and Warren Counties.....	No open season.
Mar. 2, 1928.	
Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule.....	Oct. 16-Jan. 31.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Woodcock.....	Oct. 1-Nov. 30.
Reedbird (see Order, p. 35).....	Sept. 1-Oct. 30.
Rail (marsh hen), other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Does and fawns, wild turkeys, English or ring-necked pheasant hens, Hungarian partridge, dove, swans, wood duck, elder ducks, auks, bitterns, little brown, sandhill, and whooping cranes, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game and fish, \$10.50; fish, \$3.25. Resident male citizen above age of 14: Game and fish, \$1.65. Special license to hunt woodcock from October 1 to November 9, fee \$2, required in addition to regular hunting license; issued by commission. When applied for by parent or legal guardian, in discretion of commission, license may be granted to citizen between ages 10 and 14 to hunt when accompanied by adult holder of a general license: Fee, \$1; issued only by commission. All other licenses, except as indicated, issued by county, city, or town clerk, salaried warden, or registrar of licenses. Hunting on occupied posted lands of another prohibited.

Alien prohibited from hunting or owning shotgun or rifle unless he is the owner of real property in New Jersey to the value of \$2,000 above all in-

NEW JERSEY—Continued

Hunting and fishing licenses—Continued

cartridges, in which case he may obtain non-resident and alien's license.

Bag limits and possession: One deer a year; 2 English or ring-necked pheasant cocks a day, 30 a season; 6 rabbits, 6 squirrels, 10 quail, 3 ruffed grouse, 6 woodcock, 25 ducks, 8 geese, 8 brant, 25 snipe, 15 in all of plovers and yellowlegs, 50 red-larks, 30 sora, and 25 in all of other rails (marsh hens), coot, and gallinules a day or in possession. Deer may be possessed at any time if properly tagged to show where killed; possession of other game permitted during first 10 days of close season.

Interstate transportation: Export of all protected game (except deer) prohibited, except that a non-resident licensee, in one day may carry from State the daily bag limit of game, if open to view, but not more than two days' limit of game may be exported in one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: The sale of deer, squirrels, reedbirds, and all game birds is prohibited; rabbits may be sold during open season and 10 days thereafter; Belgian hares and jack rabbits legally killed and coming from another State may be sold at any time.

Miscellaneous: Unlawful to use shotgun or rifle holding more than 2 cartridges or that may be fired more than twice without reloading.

⁴⁶ *New Jersey:* Wild deer may be taken only with shotgun not smaller than 12 gauge, which may not be loaded with a bullet or other missile larger than buckshot. Killing of a deer must be reported to commissioners or county warden within 48 hours. Landowner or his authorized agent may kill deer on his own cultivated land at any time; carcass of deer so killed is the property of the commission, and killing must be reported within 48 hours.

NEW MEXICO

Open seasons: ⁴⁶ *Dates inclusive*

Deer (with horns at least 6 inches in length) squirrel (tassel-eared gray), wild turkey.....	Nov. 20-Nov. 30.
Quail (except bobwhite).....	Nov. 1-Dec. 31.
Turtle dove and white-winged dove, black-bellied and golden plovers, yellowlegs.....	Sept. 1-Dec. 15.
Duck, goose, brant, Wilson snipe, coot, gallinule.....	Oct. 1-Jan. 15.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Does, Sonoran deer, elk, sheep, goat, antelope, buffalo, bobwhite quail, pheasant, ptarmigan, prairie chicken, sage hen, grouse, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Big game, bird, and fish, \$35.25; big game and bird, \$30.25; big game, \$25.25; bird, \$10.25; fish: General, \$5; limited, \$1.25. Resident: Big game, bird and fish, \$2.50; big game and bird, \$2.25; big game, \$1.50; bird, \$1.25; fish, \$1; guide, \$5.25; duplicate, \$1. Issued by county clerks and deputies designated by State warden. Alien resident of New Mexico or an adjoining State not permitted to hunt or to own or possess shotgun or rifle in State.

Bag limits and possession: One deer, 3 wild turkeys, a season; 20 quail, 25 doves a day or in possession; 25 ducks, 8 geese, 8 brant, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 50 sora, and 25 in all of other rails, coot, and gallinules a day. Possession permitted during open season and first 5 days of close season. Under permit, game, except migratory birds, may be held in storage for first 90 days of close season; migratory birds may be so held for a period of 10 days.

NEW MEXICO—Continued

Interstate transportation: Export of all game taken in the State prohibited, except under permit; fee \$1.25 for 1 deer and 3 turkeys, and \$1.25 for bag limit of other birds and fish.

Game taken outside of State and legally exported when accompanied by permit or proof of lawful possession, may be possessed under permit secured from State game and fish warden during open season and first 90 days of close season, but migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game taken in the State prohibited.

⁴⁶ *New Mexico:* Commission may close season in any locality on any species, and may prohibit all hunting, in periods of extreme forest fire danger, at such times and places as may be necessary.

NEW YORK

Open seasons: ⁴⁷ *Dates inclusive*

Deer (with horns not less than 3 inches long) in Adirondack region ⁴⁸ (see exception).....	Oct. 15-Nov. 15.
Exception: In towns of Jackson, Salem, and White Creek, Washington County.....	Nov. 7-Nov. 19.
Deer (with horns not less than 3 inches long) in Columbia, Delaware, Orange, Rensselaer, Sullivan, and Ulster Counties.....	Nov. 1-Nov. 15.
In Greene County.....	Nov. 1-Nov. 8.
On one land in Dutchess County ⁴⁹	Nov. 1-Nov. 15.
Bear.....	Oct. 15-Nov. 15.
Varying hare ⁴⁷	Oct. 15-Mar. 1.
Cottontail rabbit ⁴⁷	Oct. 1-Jan. 31.
Squirrel (black, gray, ⁴⁷ or fox) (see exceptions).....	Oct. 15-Nov. 15. ⁵⁰

Exception: In Schoharie County, Oct. 1-Nov. 1. In Erie, Niagara, Orleans, and Rockland Counties, no open season. Grouse, partridge⁴⁷ (see exception)..... Oct. 1-Nov. 15.

Exception: In Columbia, Delaware, Dutchess, Greene, Orange, Putnam, Rensselaer, Rockland, Sullivan, Ulster, and Westchester Counties.....	Oct. 15-Nov. 30.
Quail in Dutchess, Greene, Orange, Putnam, Rensselaer, Sullivan, and Westchester Counties only.....	Nov. 15-Nov. 30.
Pheasant, male only ⁴⁷ (four days only).....	Oct. 23 and 30; Nov. 1 and 8.
Waterfowl.....	Sept. 24-Jan. 7.
Wilson snipe or jacksnipe, coot, gallinule.....	Sept. 24-Dec. 31.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Woodcock.....	Oct. 1-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Elk, moose, caribou, antelope, fawns; Hungarian or European gray-legged partridge, dove, quail (1925); swans, wood duck, elder ducks, auks, bitterns, sandhill and whooping cranes, fulmars, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe, or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game, \$10.50; fish, \$2.50. Fishing license not required of persons under 16 years of age or in international boundary waters if residents require no license in that part of those waters not within jurisdiction of State. Resident, \$1.25. Issued by county, city, town, and village clerks. Indian resident or member of Six Nations residing on any reservation wholly or partly within State, \$1.25. Only licensed Indians residing on a reservation may hunt thereon. Licensee required to wear button. Guide (required in forest reserve counties), \$2.

NEW YORK—Continued

Hunting and fishing licenses—Continued

Issued by commissioner. Owners or lessees, and members of immediate families, actually occupying cultivated farm land may hunt thereon without license during open season. Alien not permitted to hunt except under special license from conservation commission, or to own or possess shotgun or rifle.

Bag limits: One deer, 1 bear, 3 male pheasants, a season; 3 grouse a day, 15 a season; 6 woodcock a day, 24 a season; 6 varying hares or rabbits, 5 squirrels, 25 ducks, 8 geese, 8 brant, 25 in all of rails, coots, mudhens, and gallinules, 15 in all of plovers and yellowlegs, 25 Wilson snipe or jacksnipe a day.

Local bag limits: Quail, 4 a day, 10 a season, in Dutchess, Greene, Orange, Putnam, Rensselaer, Sullivan, and Westchester Counties.

Possession: Deer, squirrel, grouse, and pheasant during open season and 5 days thereafter; migratory game birds during open season and 10 days thereafter. Deer properly tagged may be possessed under \$1 permit to February 1.

Interstate transportation: Export of game and birds prohibited, except that any person may export 1 deer, 1 bear, and one day's bag limit of other game in one day during open season by means other than parcel post. The taker may export in one day by common carrier, except parcel post, one day's limit when accompanied by permit which shall show contents of package. Head, hide, and feet of animals and plumage or skin of game birds legally taken may be exported at any time.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Importation permit, fee \$1, obtained from chief game protector, required to import game during close season, and then game birds must be accompanied by taker, while quadrupeds bearing New York importation tags may be shipped by common carrier, but not by parcel post.

Sale: Sale of all game, except varying hares and rabbits, prohibited; varying hares and rabbits legally taken in State may be sold during open season, and when brought from without the State may be sold at any time.

Head, hide, and feet of quadrupeds legally taken and possessed may be sold at any time.

Miscellaneous: Hunting prohibited on lands supplying any municipality with water or on public highways, except public highways within forest preserve counties.

⁶⁷ *New York:* Commission by order may further restrict taking or possession of game. Open seasons on upland game have been restricted to the following periods or closed as indicated: *Squirrel* (black, gray), in Genesee County, no open season. *Cottontail rabbit*, in Cattaraugus County, Oct. 1-Jan. 1; in Genesee County, Oct. 1-Dec. 31; in Orange County, Oct. 1-Jan. 15; in Richmond County, Nov. 1-Dec. 31; in Rockland County, Nov. 1-Dec. 31. *Varying hare*, in Cattaraugus County, Oct. 15-Jan. 1; in Onondaga County, Oct. 15-Jan. 31; in Genesee, Steuben, and Tompkins Counties, no open season.

⁶⁸ The Adirondack region comprises the counties of Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Oneida, Oswego, Saratoga, St. Lawrence, Warren, and Washington.

⁶⁹ In Dutchess County, deer may only be taken with shotgun loaded with slugs or shot not smaller than buckshot.

⁷⁰ In corporate limits of city or village may be taken only under permit of commission.

NEW YORK—Long Island

Open seasons:	Dates inclusive
Squirrel (black, gray, fox), quail, ruffed grouse, pheasant (male only).....	Nov. 1-Dec. 31.
Varying hare.....	Oct. 15-Mar. 1.
Cottontail rabbit.....	Nov. 1-Dec. 31.

NEW YORK—Long Island—Continued

Open seasons—Continued **Dates inclusive**

Waterfowl, Wilson snipe or jacksnipe, coot, mudhen, gallinule.....	Oct. 16-Jan. 31.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Woodcock.....	Oct. 1-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Deer, dove, swans, wood duck, eider ducks, auks, bitterns, sandhill and whooping cranes, fulmars, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Bag limits and possession: Six quail a day, 40 a season; 2 ruffed grouse a day, 15 a season; 4 male pheasants a day, 30 a season. For other bag limits see New York.

Hunting licenses, interstate transportation, sale, miscellaneous: (See New York).

NORTH CAROLINA⁸¹**Open seasons:**⁸¹ **Dates inclusive**

Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule.....	Nov. 1-Jan. 31.
Black-bellied and golden plovers, yellowlegs, dove.....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 1-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Redbird (ricebird) (see Order, p. 35).....	Aug. 16-Nov. 15.

No open season: Swans, wood duck, auks, bitterns, gannet, grebes, gulls, herons, jaegers, loons, murre, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses:⁸¹

Bag limits and possession: Twenty-five doves, 25 ducks, 8 geese, 8 brant, 6 woodcock, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 50 sorrel and 25 in all of other rails, coots, and gallinules a day. Possession of migratory birds permitted during first 10 days of close season.

Sale: Sale of ricebirds (ricebirds) and all migratory birds prohibited.

Interstate transportation: The export is prohibited of quail, partridge, pheasant, grouse, wild turkey, snipe, shore or beach birds, woodcock, taken in State. *Exceptions:* Nonresident may take out of State under his hunting license 50 quail (partridges), 12 grouse, 2 turkeys, and 50 in all of Wilson snipe, plovers, and yellowlegs in a season, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Migratory game birds taken outside of State and legally exported may be possessed during open season where taken and first 10 days of close season, unless prohibited by local laws. The importation and possession of other game is regulated by local laws, obtainable upon application to Legislative Reference Librarian, Raleigh, N. C.

⁸¹ *North Carolina:* Only the Federal seasons and other restrictions on migratory birds are given. County seasons and provisions relating to licenses, bag limits, sale, and interstate transportation are too numerous to be included. Full information regarding laws applicable to counties under jurisdiction of Audubon Society may be had on application to the Secretary, Audubon Society, Raleigh, N. C. The county laws should be consulted, as in some instances they prohibit the hunting of migratory game birds during part of the periods mentioned in the table. Robins, larks, and certain other migratory birds may not be killed at any time. (See Migratory Bird Treaty Act Regulations, footnote 2, p. 4.) The Legislative Reference Librarian also issues a pamphlet on the local laws of the State.

NORTH DAKOTA

OHIO—Continued

Open seasons: *Dates inclusive*

Prairie chicken (pinnated grouse), sharp-tailed (white-breasted) grouse, black-bellied and golden plovers, yellowlegs, Wilson snipe.....	Sept. 16-Oct. 16.
Ruffed grouse in Bottineau, Cavalier, Pembina, and Roulette Counties only.....	Oct. 7-Oct. 16.
Duck, goose, brant.....	Sept. 16-Dec. 1.
Coot, gallinule.....	Sept. 16-Dec. 31.
Woodcock.....	Oct. 1-Oct. 16.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Deer, elk, moose, antelope, quail, ruffed grouse (except as above), sagehen, English and Chinese ring-necked pheasants, Hungarian partridge, dove, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$25; resident, \$1.50. Issued by commissioners, deputy, or county auditor. Aliens not permitted to hunt. Person or member of family permanently residing with him may hunt without license during open season on own lands or lands cultivated by him. Resident license may be issued to settler. No person permitted to enter cultivated or posted lands without consent of owner.

Bag limits and possession: Five prairie chickens, sharp-tailed grouse, plovers, each or all combined a day, 10 each or all in possession at one time, 15 in all of plovers and yellowlegs, but not more than 5 plovers a day; 5 ruffed grouse a day, 15 in possession; 15 snipe, woodcock, ducks, geese, each or all combined a day, but not more than 8 geese, 8 brant, or 6 woodcock, 30 in possession; 25 in all of rails, coots, and gallinules a day. Resident licensee under permit may retain not to exceed 20 pinnated or sharp-tailed grouse, 30 waterfowl, but not more than 50 birds in all during first 5 days of close season.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may carry with him from State under license tag prairie chicken and sharp-tailed grouse not exceeding 20 in all, and ducks, geese, and brant not exceeding 30 in all, or a total of 50 of all birds combined, if open to view and labeled with his name and address and number of his license. Not more than 2 days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed under storage permit, obtained from secretary, game and fish board, in like numbers and manner as game taken in State, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited, except that hides, heads, and trophies of big game lawfully taken may be sold at any time.

OHIO

Open seasons: *Dates inclusive*

Hare, rabbit.....	Nov. 15-Jan. 1. ⁵³
Squirrel.....	Sept. 15-Oct. 20.
Ruffed grouse, cock pheasant (introduced), Hungarian partridge.....	Nov. 15-Nov. 25.
Duck, goose, brant, Wilson snipe, black-bellied and golden plovers, yellowlegs, coot, gallinule.....	Sept. 16-Dec. 31.
Woodcock.....	Oct. 1-Nov. 30.
Rail, other than coot and gallinule.....	Nov. 1-Nov. 30.

No open season: Deer, quail, dove, swans, wood duck, elder ducks, bitterns, sandhill and whooping cranes, grebes, gulls, herons, jaegers, loons,

murre, petrels, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident citizen: General, \$15.25; fish, \$2.25 (not required of children under 16 years of age). Resident citizen, \$1.25. Issued by county and township clerks. Person under 16 when hunting must be accompanied by adult. Owners, tenants, or their children may hunt without license during open season on own or leased lands. Written permission required on land of another.

Bag limits and possession: Five squirrels and 10 rabbits a day or in possession; 3 ruffed grouse, 3 cock pheasants, and 6 Hungarian partridge, 15 in all of plovers and yellowlegs, 15 Wilson snipe, 6 woodcock, 8 geese, 25 ducks, 35 sora, and 25 in all of other rails, coots, and gallinules a day. Waterfowl, coots, and gallinules may be possessed during first 10 days of close season.

Interstate transportation: Export prohibited of all protected game (except rabbit) taken in State; provided, a nonresident may take with him from State under his hunting license 25 pieces of game. But not more than two days' limit of migratory birds may be exported by one person in any one calendar week. Packages containing game or fur-bearing animals or parts thereof must be marked to show contents, initial point of billing, and names and addresses of consignor and consignee.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game (except hare or rabbit during open season).

⁵³ Ohio: Landowners, tenants, and employees may take hares or rabbits, when doing substantial damage to crops, trees, or shrubbery, at any time except on Sunday.

OKLAHOMA

Open seasons: *Dates inclusive*

Bear.....	No open season. ⁵³
Quail.....	Dec. 1-Dec. 31.
Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule.....	Oct. 1-Jan. 15.
Black-bellied and golden plovers, yellowlegs, dove.....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 1-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Deer, wild turkey (1931); antelope, prairie chicken, imported pheasant, swans, wood duck, bitterns, little brown, sandhill and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$15; alien, \$25; resident citizen, \$1.25. Issued by warden, deputy, or county clerk. A person may hunt without license during open season on own or leased premises actually occupied by him. Application of person under 14 must be approved in writing by parent or guardian. Unlawful to shoot on or across highway or railroad right of way. Unlawful to hunt on lands of another without owner's permission.

Bag limits and possession: Fifteen quail, plover, snipe, or ducks a day, 100 a season; 15 yellowlegs, but not more than 15 in all of plovers and yellowlegs a day; 8 geese, 8 brant a day, but not more than 10 in all a day; 50 sora and 25 in all of other rails, coots, and gallinules, 25 doves, and 6 woodcock a day. Possession of game permitted during first 10 days of close season, and trophies or specimens of game lawfully taken may be possessed at any time.

OKLAHOMA—Continued

Interstate transportation: Export prohibited of all protected game, but nonresident licensee may carry to his home two days' bag limit of game birds if license permit is attached.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game.

³³ **Oklahoma:** Bear in Blaine, Caddo, Comanche, Kiowa, and Major Counties, no open season; in rest of State, unprotected.

OREGON³⁴

Open seasons: District No. 1,³⁵ west of Cascades:

Deer (male, with horns)..... Sept. 10-Oct. 31.
Silver-gray squirrel..... Sept. 15-Oct. 15.

Mountain or plumed and California or Valley quail in Coos, Curry, Douglas, and Josephine Counties only..... Oct. 12-Oct. 26.

In Jackson County..... Oct. 12-Nov. 9.

Chinese pheasant, bobwhite quail (see exception)..... Oct. 12-Oct. 26.

Exception: In Clatsop, Coos, Curry, Josephine, Lincoln, and Tillamook Counties..... No open season.

Blue or sooty grouse, ruffed grouse or native pheasant (see exception)..... Sept. 10-Oct. 31.

Exception: In Benton, Clackamas, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill Counties..... No open season.

Duck, goose, brant, coot, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs..... Oct. 1-Jan. 15.
Rail, other than coot..... Oct. 1-Nov. 30.

District No. 2,³⁶ east of Cascades:

Deer (male, with horns)..... Sept. 10-Oct. 31.
Quail in Klamath County, Oct. 12-26; and in Wasco County, Oct. 12-19; in balance of district, no open season.

Blue or sooty grouse, ruffed grouse or native pheasant..... Sept. 10-Oct. 31.
Sage hen..... Aug. 1-Aug. 15.

Chinese pheasant in Baker, Grant, Hood River, Malheur, Umatilla, Union, Wallowa, and Wasco Counties only..... Oct. 12-Oct. 19.

Hungarian partridge in Umatilla County only..... Oct. 12-Oct. 19.

Duck, goose,³⁷ brant, coot, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs..... Sept. 16-Dec. 31.

Rail, other than coot..... Sept. 16-Nov. 30.

No open season: Doe and spotted fawn, moose, elk, antelope, sheep, goat, Hungarian partridge, bobwhite, Franklin grouse, foolhen, wild turkey, silver-gray squirrel, quail and introduced pheasants (except as above), prairie chicken, dove; band-tailed pigeons, swans, wood duck, anklets, auks, bitterns, little brown and sandhill cranes, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game, \$10; alien, gun license, \$25 (in addition to hunting and angling license). Resident, game and fish, \$5; game, \$3; hunting or angling, \$1.50 (county license issued to residents between 14 and 18 years of age). Angling, resident or nonresident, \$3 (not required of female). Licenses issued by

OREGON—Continued

county clerks and duly appointed agents throughout the State. Guide, \$3 (issued only to citizen of United States); issued by commission. Licenses not issued to persons under 14 years of age. Owner and member of his family may hunt, trap, or fish on own premises without license during open season. Licenses, good for life, issued free of charge by county clerks to pioneers of State who arrived prior to 1860, veterans of Indian and Civil Wars upon proof of service, and Spanish-American War veterans resident in State Soldiers' Home. Unlawful to hunt on inclosed or occupied land of another without permission of owner. Unlawful to shoot from highways or railroad right of ways.

Bag limits and possession: Two deer a season; 5 silver-gray squirrels and 10 quail in 7 consecutive days; 5 sage hens a day, 10 in 7 consecutive days; 5 in all of ruffed grouse, pheasants, and sooty or blue grouse a day, 10 in 7 consecutive days; 5 Chinese pheasants (including Hungarian partridge in Umatilla County) a day, 10 in 7 consecutive days, but in district 1 a bag of 10 shall not include more than 3 hens and in district 2 more than 2 hens; 25 ducks, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 25 in all of rails, coots, and gallinules a day, but not more than 25 in all in 1 day nor more than 30 in all in 7 consecutive days; 8 geese a day, 30 in 7 consecutive days. Migratory game birds properly tagged may be possessed during first 10 days of close season; other game, when properly tagged, during close season.

Interstate transportation: Export of all protected game prohibited, except when tagged with metal seal and accompanied by permit from State warden showing kind of game and names and addresses of consignor and consignee.

Game taken outside of State and legally exported may be imported and possessed as authorized by permit, fee \$2, and tag, fee 5 cents, obtained from State game warden, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited. Commission may make regulations permitting sale of game, except migratory birds.

³⁴ **Oregon:** Commission may open or close the season on any species of game in any county or district for such time as it may designate.

³⁵ District No. 1, west of Cascades, includes Benton, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties. District No. 2, east of Cascades, includes all other counties in the State.

³⁶ Unlawful to kill geese at any time on islands or sand bars in the Columbia east of Hood River, on Deschutes and John Day Rivers south to junction with White River and Thirty-mile Creek, respectively.

³⁷ Fee required of nonresident angler equal to that required of nonresident in his State of residence.

PENNSYLVANIA

Open seasons: ³⁸ District No. 1, west of Cascades, includes Benton, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties. District No. 2, east of Cascades, includes all other counties in the State.

Dates inclusive

Deer (male with horns having 2 or more points to one antler not less than 6 inches above the skull), bull elk (with 4 or more points to one antler)..... Dec. 1-Dec. 15.³⁹
Bear..... Nov. 1-Dec. 15.⁴⁰
Raccoon..... Oct. 1-Feb. 15.
Hare, rabbit..... Nov. 1-Dec. 15.
Squirrels (black, gray, fox), quail, ruffed grouse, male ring-necked pheasant, Hungarian partridge or quail, wild turkey..... Nov. 1-Nov. 30.
Red or pine squirrel..... Nov. 1-Aug. 15.
Duck, goose, brant..... Oct. 1-Jan. 15.
Wilson snipe or jacksnipe, coot (mud hen), gallinule..... Oct. 1-Nov. 30.

PENNSYLVANIA—Continued

Open seasons—Continued	Dates inclusive
Black-bellied and golden plovers, yellowlegs.....	Sept. 16–Nov. 30.
Woodcock.....	Oct. 1–Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1–Nov. 30.
Redbird (see Order, p. 35).....	Sept. 1–Oct. 30.
Blackbird.....	Aug. 1–Nov. 30.

No open season: Cow elk and calves having less than 4 points to one antler, doe, fawn, pheasant hens, dove, swans, wood duck, elder ducks, auks, bitterns, little brown and sandhill cranes, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jack-snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: *Game:* Nonresident, \$15. Issued by commission or county treasurer. Resident from county treasurer, \$1.25; through justice of the peace, magistrate, or notary public, \$1.40. Licenses not issued to minor under 14 years of age, and minor between 14 and 16 must furnish written consent of parent or guardian. Licensee required to wear tag displayed on middle of back.

Resident citizen and members of family or employees residing upon and cultivating land in State as either owner or lessee may hunt during open season on such land and, with consent of owner, on adjoining land without a license. Taxidermist, \$1.

Licensed hunters, within 30 days after expiration of license, must report amount of game killed. Aliens not permitted to hunt or be possessed of dogs or firearms.

Fishing: Nonresident, \$5 (10 cents extra to county treasurer, 15 cents extra to justice of peace); issued by county treasurer, justice of the peace, commissioner of fisheries or his agents.

Resident, \$1 (10 cents extra to county treasurer); issued by county treasurer, commissioner of fisheries, his officers or agents. License not required of minors under 21. Person and members of his family residing on own land may angle in waters on or adjacent thereto during open season without license.

Bag limits and possession: One deer (6 to party camping or hunting together), 1 elk (1 to hunting party), 1 bear (4 to hunting party), 40 rabbits, 15 hares, 20 squirrels, 1 turkey, 25 quail (partridge), 15 ruffed grouse, 6 male ring-necked pheasants, 20 woodcock a season. Five rabbits, 3 hares, 6 squirrels (black, gray, fox), 8 quail (partridge), 3 ruffed grouse, 2 male ring-necked pheasants, 6 woodcock, 25 ducks, 8 geese, 8 brant, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 50 sora, 25 in all of other rails, coots, and gallinules a day. Possession of migratory birds permitted during first 10 days of close season; other game during first 30 days thereof.

Interstate transportation: Export of all protected game taken in State prohibited; provided, a non-resident licensee may take out with him on the same conveyance two days' limit of game except elk. Small game must be accompanied by owner, and if concealed must be tagged to show name and address of owner, county where killed, and number of each species in package. Large game may be shipped by express when plainly marked to show name and address of owner and county in which killed. Specimens of game legally taken may be shipped to a licensed taxidermist for mounting, but shipment of game by parcel post prohibited, except that skins of raccoon, bear, and trophies to licensed taxidermists may be so shipped, if marked to show contents, but no such shipment may be made to points outside the State without a permit.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale prohibited of wild deer, rabbit, raccoon, and bear taken in the State; and of all other game

PENNSYLVANIA—Continued

wherever taken. Trophies of game not killed in State may be purchased or sold at any time. **Miscellaneous:** Automatic gun prohibited.

⁵⁵ *Pennsylvania:* Seasons may be closed or shortened in any county on petition to commission.

⁵⁶ In killing deer, elk, or bear, only one all-head lead-alloy, soft-nosed, or expanding bullet may be used at each discharge. The use of steel-jacketed bullets is prohibited.

RHODE ISLAND

Open seasons:	Dates inclusive
Gray squirrel, hare, rabbit, quail or bobwhite, ruffed grouse or partridge, pheasant.....	Nov. 1–Dec. 31.
Duck, goose, brant, coot, gallinule.....	Oct. 1–Jan. 15.
Black-bellied and golden plovers, yellowlegs.....	Aug. 16–Nov. 30.
Wilson snipe.....	Oct. 1–Nov. 30.
Woodcock.....	Nov. 1–Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1–Nov. 30.

No open season: Deer;⁵⁶ dove; Hungarian partridge; swans, wood duck, elder ducks, auks, bitterns, little brown and sandhill cranes, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jack-snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: *Game:* \$10.25; fish, \$1.15.⁵⁷ *Alien:* Game, \$15.25; fish, \$2.15. Resident: Game, \$1.25; fish, 25 cents. Issued by city and town clerks. Fishing license not required of women, nor of males under 18. License not required of resident or his immediate family to hunt on own or leased agricultural lands on which actually domiciled; nonresident owning real estate valued at not less than \$500, and nonresident member or guest of club incorporated for hunting or fishing purposes prior to Jan. 1, 1909, which owns real estate assessed for taxation at value of not less than \$1,000, may procure license at a fee of \$1.25; licenses not issued to minors under 15 years of age. Consent of owner required for hunting upland game birds on land of another from January 1 to October 31.

Bag limits and possession: Fifteen ducks, 8 geese, 8 brant, 6 woodcock, 15 in all of plovers and yellowlegs, 15 Wilson snipe, 15 in all of rails, coots, and gallinules a day, but not more than 15 game birds of all kinds in possession at one time. Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season.

Interstate transportation: Export prohibited of all game; provided, a nonresident licensee may take out under his license 10 wild fowl or birds in one calendar year, if carried open to view.

Game taken outside of State and legally exported may be imported and possessed as authorized by permit from commissioner of birds, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all game birds prohibited.

⁵⁸ *Rhode Island:* Deer injuring crops may be killed at any time by the owner or occupant of the premises under written permit from secretary of State.

⁵⁹ Fee required of nonresident angler equal to that required of nonresident in his State of residence.

SOUTH CAROLINA

Open seasons:	Dates inclusive
Deer (male).....	Sept. 1–Jan. 15.
Bear, rabbit, squirrel, quail (partridge), wild turkey, blackbird.....	Nov. 27–Mar. 1. ⁶⁰
Raccoon, opossum.....	Sept. 1–Mar. 1.

SOUTH CAROLINA—Continued

Open seasons—Continued	Dates inclusive
Duck, goose, brant, coot, gallinule, Wilson snipe, dove.....	Nov. 1-Jan. 31.
Black-bellied and golden plovers, yellowlegs.....	Sept. 1-Dec. 15.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Woodcock.....	Nov. 1-Dec. 31.
Redbird (see Order, p. 35).....	Aug. 16-Nov. 15.
No open season: Does; ruffed grouse (pheasant), swans, wood duck, auks, bitterns, little brown, sandhill, and whooping cranes, gannet, grebes, gulls, herons, jaegers, loons, murres, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).	
Hunting and fishing licenses: Nonresident: Game, \$15.25; fish, \$3.25. Issued by county clerk or game warden. Resident: Game, State, \$3.10; county of residence, \$1.10. Issued by county clerk or game warden.	

No license required of resident owners, tenants, their children, or, under written permission, their employees, to hunt during open season on own lands. Confederate veteran wearing his cross of honor may hunt and fish in any county of State without license.

Consent of owner or manager required to hunt on land of another.

Bag limits and possession: Three deer, 20 wild turkeys a season; 15 squirrels, 15 quail (partridge), 2 turkeys, 25 doves, 25 ducks, 8 geese, 8 brant, 6 woodcock, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 60 sora, and 25 in all of other rails, coots, and gallinules a day. Possession of migratory birds permitted during first 10 days of close season.

Interstate transportation: Export of all resident nonmigratory game taken in State prohibited, except that a landowner or licensee may export under shipping tag from State warden one day's bag limit of resident nonmigratory game a week, if not for sale. Unlawful for any transportation company to receive for shipment out of the State any deer or other resident nonmigratory game unless duly tagged. Under Federal regulations not more than 2 days' limit of migratory birds may be taken or shipped out of the State in any one calendar week. All packages containing migratory birds must be marked to show actual contents and names and addresses of consignor and consignee. No game may be removed from the State for sale.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of deer, quail (partridges), dove, turkey, reebirds, and all other migratory birds.

⁶³ South Carolina: Between September 1 and Thanksgiving Day rabbits may be hunted without firearms, and squirrels may be hunted without dogs.

⁶⁴ Season opens on Thanksgiving Day.

SOUTH DAKOTA

Open seasons:	Dates inclusive
Deer (male).....	Nov. 1-Nov. 30.
Partridge, grouse, prairie chicken, black-bellied and golden plovers, yellowlegs.....	Sept. 16-Oct. 15.
Duck, goose, brant, coot, gallinule, Wilson snipe.....	Sept. 16-Dec. 31.
Woodcock.....	Oct. 1-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 16-Nov. 30.

No open season: Does, elk, antelope, mountain sheep, quail, dove, pheasant, upland plover, swans, wood duck, other ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

SOUTH DAKOTA—Continued

Hunting licenses: Nonresident or alien: Big game, \$25; small game, \$15. Issued by game warden or county treasurer. Resident: Big game, \$5; small game, \$1; issued by county treasurer or State warden; special license, small game, \$3 (hunting; also authorizes shipment of 50 birds as specified in license); issued by State warden. Hunting game birds during open season on own land permitted without license. Unlawful to hunt on cultivated land of another without permission of owner.

Bag limits and possession: One deer a year; 25 ducks, geese, brant, coot, gallinules, sora, and other rails in the aggregate of all kinds (but not more than 8 geese or brant), and 5 each of other species of game birds a day; 50 in all of ducks, geese, or brant, or other aquatic fowl and snipe, and 15 in all of prairie chickens, partridge, grouse, and plover in possession. Possession permitted during open season and five days thereafter.

Interstate transportation: Export of all protected game prohibited; provided a nonresident may export 1 deer lawfully killed under permit of State game warden and not more than 10 birds under each of the five coupons attached to his nonresident license; but not more than 50 ducks, 16 geese, 16 brant, 12 woodcock, 50 snipe, 30 in all of plovers and yellowlegs, and 50 in all of rails, coots, and gallinules may be exported by one person in any one calendar week, and if exported by common carrier tags attached to hunting license must be affixed to each shipment.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited; provided, skins, heads, and antlers of deer lawfully killed may be sold.

TENNESSEE

Open seasons:	Dates inclusive
Deer (male, with horns having two or more spikes each).....	Dec. 20-Dec. 31.
Squirrel.....	June 1-Jan. 1.
Rabbit.....	Unprotected.
Quail or partridge (see exceptions).....	Nov. 25-Jan. 15.

Exceptions: Quail, in Chester County, Nov. 20-Feb. 15; in Fayette and Harde-man Counties, Nov. 22-Mar. 1; in Madison County, Dec. 1-Feb. 1.

Duck, goose, brant, coot, mud-hen, gallinule, Wilson snipe or jacksnipe.....	Nov. 1-Jan. 31.
Black-bellied and golden plovers, yellowlegs, dove.....	Sept. 1-Dec. 15.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Does and fawns (1925); wild turkey (1928); grouse, ring-necked and Mongolian pheasants, woodcock, swans, wood duck, bitterns, sandhill and whooping cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$15 (may hunt on own land without license). Resident, State, \$2 (resident must hold State license to hunt on Reelfoot Lake); county \$1 (county licensee may obtain State license for \$1). Issued by county clerks. Licensee required to wear license tag displayed in center of back of outer garment.

Owners and tenants may hunt without license on land on which they reside. Unlawful to hunt on tillable or inclosed lands of another without permission.

Reelfoot Lake.—Nonresident, fish, \$2. Guide or pusher, \$1 (issued to residents only).

Bag limits and possession: Two deer a season; 20 game birds or animals a day, but not more than 8 geese, 8 brant, 15 in all of plovers and yellowlegs a day; in Washington County, 15 quail a day.

TENNESSEE—Continued

Interstate transportation: Export of all protected game prohibited; provided, nonresident licensee may take out of State, if carried openly, game birds legally killed by him (except that 25 birds only may be exported from Reelfoot Lake), but not more than 50 ducks, 16 geese, 16 brant, 10 Wilson snipe, 30 in all of plovers and yellowlegs, 50 in all of rails, coots, and gallinules, and 50 doves may be exported by one person in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game killed in State prohibited.

TEXAS

Open seasons: *Dates inclusive*
Deer (male) (see exception)..... Nov. 1-Dec. 31.

Exception: In Bosque County, no open season.
Squirrel in Angelina, Cherokee, Dallas, Hardin, Jasper, Jefferson, Liberty, Nacogdoches, Newton, Orange, Rockwall, and Tyler Counties.....

Aug. 1-Dec. 31.
Unprotected.

In rest of State.....
Quail or partridge, chachalaca or Mexican pheasant (see exceptions).....

Dec. 1-Jan. 31.

Exceptions: Quail in Fayette County.....

Dec. 1-Dec. 31.

Quail in Grayson County and blue quail in Lampass County, no open season.

Prairie chicken in Gray, Hemphill, Lipscomb, and Wheeler Counties only.....

Sept. 1-Sept. 10.

Wild turkey gobblers (see exceptions).....
Exceptions: In Angelina, Cherokee, Dallas, Gillespie, Hardin, Jasper, Jefferson, Kendall, Liberty, Nacogdoches, Newton, Orange, Rockwall, and Tyler Counties.....

Nov. 1-Dec. 31.

In Brooks, Cameron, Hidalgo, Jim Hogg, Kenedy, McMullen, Starr, and Willacy Counties.....

Mar. 1-Apr. 30.

Dove (see exception).....

Nov. 1, 1926.

Exception: West and north of International & Great Northern and Texas & Pacific Railroads (except Fayette County, Dec. 1-Dec. 15).....

Nov. 1-Dec. 31.⁶⁴

Duck, goose, brant, Wilson snipe or jacksnipe, coot, gallinule (see exception).....

Sept. 1-Dec. 15.

Exception: West and north of International & Great Northern and Texas & Pacific Railroads.....

Nov. 1-Jan. 31.⁶⁴

Black-bellied and golden plovers, yellowlegs.....

Oct. 1-Jan. 15.

Rail, other than coot and gallinule.....

Oct. 16-Dec. 15.

No open season: Does; antelope, sheep (1928);

Oct. 16-Nov. 30.

turkey hens, robins, prairie chicken, pinnated grouse, pheasant (except chachalaca), woodcock (1928); swans, wood duck, bitterns, little brown sandhill, and whooping cranes, gannet, grebes, gulls, herons, jaegers, loons, petrels, band-tailed pigeons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident or alien, \$15; issued by game, fish, and oyster commissioner, deputies, and county clerks. Resident, \$2, not required in

TEXAS—Continued

county of residence; issued by commissioner, deputies, and county clerks.

Bag limits and possession: Three deer a season; 3 turkey gobblers a season, except that only 2 may be taken in Angelina, Cherokee, Dallas, Hardin, Jasper, Jefferson, Liberty, Nacogdoches, Newton, Orange, Rockwall, and Tyler Counties; 5 squirrels a day; 15 in all of quail and chachalaca; 5 prairie chickens a day, 15 a season; 15 doves, 25 in all of waterfowl and shorebirds, but not more than 8 geese, 8 brant, or 15 plovers and yellowlegs; 50 sora and 25 in all of other rails, coots, and gallinules a day. Possession of all game permitted during open season and 10 days thereafter.

Interstate transportation: Export prohibited of all game, except that nonresident licensee may ship game to his home for own use under affidavit that it was lawfully killed and will not be bartered or sold; provided that not more than two days' limit of migratory birds may be exported in any one calendar week. Game may be shipped to taxidermist for mounting under affidavit that shipper killed the specimen and that it is not being preserved for sale.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game.

⁶⁴ Texas: See Regulation 4 of Migratory Bird Treaty Act Regulations, footnote 2, p. 4.

UTAH

Open seasons: *Dates inclusive*

Deer (buck, with horns not less than 5 inches long)⁶⁵..... Oct. 20-Oct. 30.

Bear..... Sept. 1-May 1.⁶⁷

Rabbit, hare..... Unprotected.

Duck, goose, brant, coot, gallinule, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs (see exceptions)..... Oct. 1-Dec. 31.

Exceptions: In Beaver, Emery, Grand, Iron, Kane, Millard, San Juan, Uinta, and Washington Counties..... Oct. 1-Jan. 15.

Duck in Fish Lake Game Preserve..... Oct. 1-Nov. 30.

No open season: Does, fawns, elk,⁶⁶ antelope, sheep, goats, quail, any species of grouse or sage hens, Hungarian partridge, mourning dove,⁶⁸ swans, wood duck, rail, bitterns, sandhill crane, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident citizen: Game birds and fish, \$5; deer and bear, \$10; fish, \$3. Resident citizen (male): Game and fish, 12 to 16 years, \$1; 16 and over, \$2; females, 16 and over, \$1; guide \$5. Aliens prohibited from hunting or fishing in State. Resident citizens, males under 12 and females under 16, not required to obtain licenses to fish. Issued by State fish and game commissioner or deputy, county clerk, or deputy or authorized agent.

Bag limits and possession: One buck a season; 25 ducks, geese, and brant a day, but not including more than 8 geese or brant; 15 Wilson snipe, 15 plovers and yellowlegs a day. Not more than 25 game birds in all may be taken in one day, and not more than 50 may be possessed at one time.

Interstate transportation: Export of all game prohibited, except under permit and regulations of commissioner.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Person possessing game during close season in State must show lawful taking.

UTAH—Continued

Sale: Sale of all game prohibited; except that rabbit, bear, and hides of deer legally killed may be sold.

⁶⁶ *Utah:* Commissioner may shorten or close the open season and reduce the bag limit on any species of game birds or animals needing additional protection.

⁶⁷ Person under 16 years of age not permitted to kill deer.

⁶⁸ Bear destroying livestock may be killed at any time by stock owners or Government trappers.

⁶⁹ Elk doing damage may be killed under authority of commissioner.

⁷⁰ Commissioner, upon determining that quail, any species of grouse or sage hens, Hungarian partridges, or mourning doves have increased sufficiently, may prescribe an open season and fix bag limits on any such birds.

VERMONT

Open seasons: *Dates inclusive*

Deer (with horns not less than 3 inches long) ⁷⁰	Nov. 3-Nov. 15.
Hare, rabbit.....	Oct. 1-Feb. 28.
Gray squirrel, ruffed grouse or partridge, woodcock.....	Oct. 1-Oct. 31.
Quail.....	Sept. 15-Nov. 30.
Duck, goose, brant, coot, gallinule.....	Sept. 16-Dec. 31.
Black-bellied and golden plovers, yellowlegs, English or Wilson snipe (jacksnipe).....	Sept. 16-Nov. 30.

No open season: Elk, moose, caribou (1932); does, fawns, dove, rail; pheasants, European partridge (1932); swans, wood duck, auks, bitterns, sandhill and whooping cranes, grebes, gulls, herons, jaegers, loons, murrets, petrels, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: Game and fish, \$10.50; owner of real estate in State to the value of \$1,000, \$1.25; fish, \$2.50. Resident: Game and fish, \$1.25; game, 75 cents; fish, 75 cents. Issued by town clerks.

Hunting licenses not issued to persons under 16 without written consent of parent or guardian. Owners of farm lands and their resident minor children or tenants may hunt without a license on own lands during open season. Fishing licenses not required of persons under 15.

Bag limits and possession: One deer a season; 4 each of ruffed grouse and woodcock a day, 25 each a season; 5 hares or rabbits a day or in possession; 4 gray squirrels, 4 quail, 20 ducks, 3 geese, 8 brant a day; 10 in all of plovers, yellowlegs, and Wilson snipe a day; 25 in all of coots and gallinules a day.

Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season.

Interstate transportation: Export prohibited of all protected game, except hares and rabbits; provided, a nonresident licensee may export one deer under license coupon and one day's bag limit of game birds under permit, but must accompany shipment; resident may export (if not for sale) one day's bag limit of game birds under special permit from commissioner and one deer a season for sale, if it is tagged and license is presented to carrier for cancellation, but laws of State to which deer is shipped must be complied with. Packages containing game delivered to a common carrier for transportation must be tagged to show the number and kind of such game therein, names of consignor and consignee, station from which shipped, destination, and number of license. The license of the shipper must be presented to the agent of the transportation company for indorsement thereon of the quantity of game offered for transportation. Head, hides, feet, and fur of quadrupeds and plumage and skins of game birds legally killed and possessed, may be transported without tags, if accompanied by owner.

Game taken outside of State and legally exported may be possessed as authorized by permit obtained from fish and game commissioner, except that migratory game birds may be possessed only

VERMONT—Continued

during open season where taken and first 10 days of close season.

Sale: Sale of squirrels and all protected game birds prohibited; deer may be sold during open season and for a "reasonable time thereafter," and hares and rabbits during the open season. Head and hide of deer legally taken may be sold.

⁷⁰ *Vermont:* Landowner, member of his family, or authorized employee may kill deer doing damage to his fruit trees or crops; but the person under whose direction a deer is so killed must, within 12 hours, report the matter in a signed statement to the nearest fish and game warden. Deer may also be killed at any time in orchard zones established by the commissioner, but such killing must forthwith be reported to the owner of the orchard and the county warden.

VIRGINIA

Open seasons: ⁷¹ *Dates inclusive*

Deer (male, with horns visible above the hair).....	Nov. 15-Dec. 31.
Elk (see exception).....	Dec. 15-Dec. 31. ⁷²
<i>Exception:</i> In national forest areas.....	
Squirrel ⁷³	No open season. Sept. 1-Jan. 31.
Rabbit, quail or partridge, pheasant or grouse, wild turkey.....	Nov. 15-Jan. 31.
Ring-necked pheasant in Shenandoah County.....	Nov. 15-Nov. 25. Sept. 1-Dec. 15.
Dove.....	Nov. 15-Nov. 25. Sept. 1-Dec. 15.
Duck, goose, brant, Wilson snipe or jacksnipe, coot, mudhen, gallinule.....	Nov. 1-Jan. 31. ⁷⁴
Black-bellied and golden plovers, yellowlegs.....	Aug. 16-Nov. 30.
Woodcock.....	Nov. 1-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Reedbird (see Order, p. 35).....	Aug. 16-Nov. 15.

No open season: Does, fawns, swans, wood duck, elder ducks, auks, bitterns, sandhill crane, fulmars, gannet, grebes, gulls, herons, loons, murrets, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident:⁷⁵ Game, \$10; angling, \$2.50 (not required in tidal waters, or of guest of resident). Alien: Game, \$20 (alien owner of real estate resident for five years, same as resident). Resident: Game, State, \$3, county of residence, \$1. Issued by clerks of circuit and corporation courts.

Residents and nonresidents and their children may hunt on own land during open season without license; tenant, under written consent of owner or landlord, may hunt (during open season without license) on lands on which he resides.

Bag limits and possession: One elk a season; 1 deer a day, 2 a season; 2 turkeys a day, 6 a season; 4 grouse a day, 20 a season; 15 quail a day, 150 a season; 25 doves a day, 250 a season; 6 woodcock a day, 25 a season; 25 ducks a day, 350 a season; 8 geese a day, 50 a season; 8 brant a day, 30 a season, but not more than 35 in all of ducks, geese, and brant a day on Back Bay, Princess Anne County; 15 in all of plovers and yellowlegs a day, 200 a season; 25 Wilson snipe a day, 250 a season; 50 sora a day, 500 a season, and 25 in all of other rails, coots, and gallinules a day, 250 a season. Possession of migratory game birds permitted during open season and 10 days thereafter, and of other game during the open season and 5 days thereafter.

Interstate transportation: Export of all protected game (except rabbits and squirrels) prohibited; provided, during the open season any licensee may, under his hunting license, take with him out of State, or as baggage on the same conveyance, 1 deer, 50 quail or partridges, 10 pheasants or grouse, 3 wild turkeys, 50 waterfowl, but not exceeding 100 in all, if killed or captured by himself, shipped open to view, and plainly labeled with his name and address; but more than 2 days'

VIRGINIA—Continued

Interstate transportation—Continued

limit of geese and brant may not be exported by one person in one calendar week. Any citizen of State may ship from State during open season as a gift and not for sale (which fact must be stated on shipping tag), 1 deer, 18 quail or partridges, 6 pheasants, 3 wild turkeys, and 12 waterfowl, if open to view and plainly labeled with names and addresses of donor and donee and number and kind of each so shipped.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all game prohibited, except of rabbits and squirrels during open season.

⁷¹ **Virginia:** The Board of Supervisors of any county, upon written petition of 100 licensed resident hunters or landowners thereof, may shorten the current open season in their county, by providing an earlier closing date, make other restrictions not repugnant to law, and may include in such protection game not specifically mentioned. Also in extreme emergency, such as unusually heavy and continued snows or extraordinary severe weather threatening the extinction of game birds or game animals, the board may terminate by order the current hunting season which order shall take effect 10 days after publication in a newspaper published in the county affected. Certified copies of all orders of boards of supervisors affecting hunting seasons must be mailed to the department of game and inland fisheries, Richmond, Va. (Code Section 3356, as amended in 1924.) For information concerning such changes communicate with board of supervisors, county clerks, or department of game and inland fisheries.

⁷² Elk doing damage to private property may be killed at any time under permit of commissioner of game and inland fisheries.

⁷³ Residents of the State may kill rabbits and squirrels on their own lands at any time.

⁷⁴ Wild fowl may not be hunted on Wednesdays, Saturdays, and Sundays on Back Bay, Princess Anne County.

⁷⁵ Residents of States having larger nonresident hunting license fee must pay fee charged in own State.

WASHINGTON

Open seasons: ⁷⁶*West of Cascades—*

Deer, bear, and upland game birds, open seasons fixed by county game commissions.⁷⁶

Duck, goose, brant, coot, black-bellied and golden plovers, Wilson snipe or jacksnipe, yellowlegs.

Rail, other than coot.

East of Cascades—

Deer, bear, and upland game birds, open seasons fixed by county game commissions.⁷⁶

Duck, goose, brant, coot, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs (see exception).

Exception: In Asotin, Benton, Chelan, Columbia, Garfield, Kittitas, Walla Walla, and Yakima Counties.

Rail, other than coot (see exception).

Exception: In Asotin, Benton, Chelan, Columbia, Garfield, Kittitas, Walla Walla, and Yakima Counties.

No open season: ⁷⁶ Moose, elk (1925); does (east of Cascades and in Chlallam, Skagit, Snohomish, and Whatcom Counties), fawns, caribou, mountain sheep, mountain goat, squirrels (gray, black, fox), and dove; swans, wood duck, elder ducks,

Dates inclusive

Oct. 1-Jan. 15.

Oct. 1-Nov. 30.

Sept. 16-Dec. 31.⁷⁷

Oct. 1-Dec. 31.

Sept. 16-Nov. 30.

Oct. 1-Nov. 30.

WASHINGTON—Continued

auklets, auks, bitterns, little brown and sandhill cranes, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, band-tailed pigeons, puffins, shearwaters, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident or alien: Hunting and fishing, State, \$10; fishing, county, \$2.50. Resident: State, \$7.50; county, \$1.50; guide, \$10. Issued by county auditors.

Aliens must have permit to carry firearms. Fishing license not required of women and persons under 16, if residents.

Bag limits and possession: For bag limits on deer, bear, and upland game birds, communicate with county game commission at county seat, or supervisor of game and game fish, Box 384, Seattle. Twenty ducks, geese, brant, golden plover, yellowlegs, Wilson snipe a week (week ends at midnight Saturday), but not more than 8 geese, 8 brant, 15 in all of plovers and yellowlegs a day; 30 ducks, geese, and brant in possession; 50000 and 25 in all of other rails, coots, and gallinules. Possession during close season permitted upon filing with county game commission description and number of each kind of game, which may be tagged or stamped by commission for identification, but migratory birds may not be possessed longer than the first 10 days after close of open season.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may export one day's limit of game birds upon attaching an affidavit that they were lawfully killed by himself and are not being exported for sale.

Game taken outside of State when accompanied by affidavit of chief game official may be possessed at any time for noncommercial use, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited.

⁷⁸ **Washington:** County game commission, with consent of director of fisheries and game, may shorten, close, or open season and fix bag limits on game and fur animals, and upland game birds. Communicate with county game commission at county seat, or supervisor of game and game fish, Box 384, Seattle.

⁷⁷ No open season on waterfowl on Columbia or Snake Rivers or within one-fourth mile of their shores in counties of Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Walla Walla, Whitman, and Yakima.

WEST VIRGINIA

Open seasons: ⁷⁹ *Dates inclusive*

Rabbit (except on own land at any time). Oct. 1-Dec. 31.

Squirrel. Sept. 22-Nov. 30.

Ruffed grouse (pheasant), wild turkey.⁷⁹ Oct. 15-Nov. 30.

Quail (Virginia partridge).⁷⁹ Nov. 1-Nov. 30.

Duck, goose, brant. Oct. 15-Dec. 31.

Coot, gallinule. Sept. 16-Dec. 31.

Wilson snipe or jacksnipe. Oct. 15-Dec. 14.

Black-bellied and golden plovers, yellowlegs. Sept. 16-Dec. 31.

Woodcock. Oct. 15-Nov. 30.

Rail (ortolan), other than coot and gallinule. Sept. 16-Nov. 30.

No open season: Elk (1931); deer (1926); dove, imported pheasants, capercaillie, and other introduced foreign game birds; swans, wood duck, bitterns, sandhill crane, grebes, gulls, herons, jaegers, loons, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident, game and fish, \$15; resident, game and fish, \$1; issued by county clerk. Aliens not permitted to hunt. License not required of minor under 15. Landowner, his resident children and tenants, may hunt or fish on own land during open season without a license. Unlawful to hunt or fish on inclosed or improved lands of another without written permission of owner.

WEST VIRGINIA—Continued

Bag limits and possession: Eight squirrels a day, 60 a season; 10 quail a day, 60 a season; 4 ruffed grouse a day, 20 a season; 1 wild turkey a day, 4 a season; 25 ducks, 8 geese, 8 brant, 6 woodcock, 25 Wilson snipe, 15 in all of plovers and yellowlegs, 50 sora, and 25 in all of other rails, coot, and gallinules a day. Possession of migratory birds permitted during first 10 days of close season; other game legally taken may be possessed at any time.

Interstate transportation: Export prohibited of elk, deer, squirrels, quail, ruffed grouse (pheasant), wild turkey, geese, brant, ducks. Not more than two days' limit of migratory birds (except waterfowl) may be exported by one person in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale prohibited of all protected game, except that rabbits may be sold during open season.

Miscellaneous: Unlawful to discharge firearms across any public road, within 400 feet of any schoolhouse or church, within 500 feet of a dwelling house, or on or near any park or place where people gather for pleasure.

²⁸ *West Virginia:* The sex and number of wild turkeys killed in State must be reported to commission in December of each year.

²⁹ Commission may change the dates in any county for the open season on quail, but may not permit more than 30 days' hunting.

WISCONSIN

Open seasons: *Dates inclusive*

Deer (male, not less than 1 year old) in Pierce, Barron, Eau Claire, Clark, Wood, Lincoln, Langlade, Oconto (north of Township 30), and all counties north thereof (except Marathon)..... Nov. 13-Nov. 22.

In Marathon and rest of State, no open season.

Rabbit (see exceptions)..... Oct. 1-Dec. 31.

Exceptions: In Jefferson County..... Nov. 15-Jan. 15.
In Crawford, Grant, Richland, and Vernon Counties, unprotected.

Squirrels (see exception)..... Oct. 15-Jan. 1.

Exception: In Dodge, Fond du Lac, Jefferson, Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, Waukesha, and Wauwasha Counties, no open season.

Partridge or ruffed grouse, spruce hen (see exception)..... Oct. 4-Oct. 8.

Exception: In Calumet, Manitowoc, and Winnebago Counties, no open season.

Prairie chicken or pinnated grouse, sharp-tailed grouse (see exception)..... Sept. 20-Sept. 24.

Exception: In Barron, Calumet, Crawford, Dane, Dunn, Fond du Lac, Grant, Green, Iowa, Jefferson, Kenosha, La Crosse, Lafayette, Lincoln, Manitowoc, Milwaukee, Monroe, Oneida, Ozaukee, Polk, Portage, Racine, Richland, Rock, Sauk, Vernon, Walworth, Washington, Waukesha, Waupaca, and Winnebago Counties..... No open season.

WISCONSIN—Continued

Open seasons—Continued *Dates inclusive*

Hungarian partridge in Jefferson and Waukesha Counties only..... Sept. 7-Sept. 11.

Duck, coot or mudhen, gallinule, Wilson snipe or jack-snipe, black-bellied and golden plovers, yellowlegs..... Sept. 16-Dec. 20.
Goose, brant..... Sept. 16-Dec. 31.

Rail, other than coot and gallinule..... Sept. 16-Nov. 30.

No open season: Elk, moose, quail, pheasants (Chinese, English, Mongolian), Hungarian partridge (except as above), woodcock, dove, swans, wood duck, eider ducks, auks, bitterns, little brown, sandhill, and whooping cranes, grebes, guillemots, gulls, herons, loons, murres, terns, and all shorebirds (except Wilson snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: All game, \$50; all game (except deer), \$25; fish, \$3 (not required in outlying waters or of person under 6); settler, \$1; guide, \$1. Issued by commission. Resident: Game, \$1 (deer tag, 50 cents additional). Issued by county clerks.

Hunting licenses not issued to persons under 15 or to aliens. Hunting prohibited in fields of growing grain or on lands of another without consent of owner.

Bag limits and possession: One male deer a season; 5 squirrels a day; 5 rabbits a day in counties where protected; other counties, no limit; 5 partridge and spruce hens a day; 5 prairie chickens and sharp-tailed grouse a day; 5 Hungarian partridges a day; 8 geese, 8 brant a day. Ducks (including coot or mud hen), 15 a day; plovers, snipe, rail, rice hen, 15 a day; 15 yellowlegs, but not more than 15 in all of plovers and yellowlegs a day.

Possession at any time of deer duly tagged permitted for private use by person killing it. Possession at any time prohibited of game by person without hunting license or scientist's certificate.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may transport, between November 14 and 25, inclusive, 1 deer duly tagged if he accompanies shipment and may take in his personal possession, openly, a mixed bag of not more than 20 game birds legally killed, but not more than the bag limit for one day of any one variety.

Game taken outside of State and legally exported may be possessed as authorized by permit from conservation commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited (except rabbit). Rabbits may be sold during open season.

WYOMING

Open seasons: *Dates inclusive*

Deer (with horns)..... Sept. 15-Oct. 15.

Elk in Lincoln, Teton, Sublette, Park, and Fremont Counties (except between Roaring Fork Creek and Big Sandy River on the west slope of Wind River Mountains in Bridger National Forest, and north of Big Wind River and south of Sweetwater River in Fremont County)..... Sept. 15-Nov. 15.

Sheep (mature male with horns not less than one-half curl) in Lincoln, Teton, Sublette, Park, and Fremont Counties only..... Sept. 15-Nov. 15.

Grouse (other than sage grouse)..... Sept. 15-Nov. 15.
Sage grouse..... Aug. 1-Aug. 15.

Duck, goose, coot, gallinule, black-bellied and golden plovers, Wilson snipe, yellowlegs..... Sept. 16-Dec. 16.

Rail, other than coot and gallinule..... Sept. 1-Nov. 30.

WYOMING—Continued

No open season: Elk (except as above), does and fawns, buffalo, moose,⁸¹ antelope,⁸¹ quail, Mongolian pheasants (1925); dove, swans, wood duck, bitterns, little brown and sandhill cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: General, \$50 (not issued to minor under 16; authorizes hunting of bears, Sept. 15–Nov. 15, limit, 3 bears); nonresident hunting big game must be accompanied by a guide, but not more than 3 may hunt under one guide; birds, \$5 (not issued to minor under 16); fish, \$3 (not required of minor under 12). Bear, \$25 (issued by commissioner; authorizes killing of 3 bears at such times as may be designated). Alien: Fish, \$5; resident alien, fish, \$3. Resident: General, \$2.50 (not issued to minor under 16); birds, \$1.50 (not issued to minor under 14); fish, \$1 (not required of G. A. R. veterans, or minors under 12 years of age). Guide: Citizens only, \$25 (bond, \$500—may guide party of 3 nonresidents at one time). Permit to photograph game or birds, under supervision of commissioner, January 1–April 30, \$5. Permit to hunt bear in State game preserves, \$5; permit to hunt bear in national forests outside of State game preserves, \$5, and \$1 for each dog. Taxidermist, \$10. Licenses issued by commissioner, justice of peace, assistant and deputy wardens, and county and city clerks. Unlawful to hunt on inclosed lands of another without consent of owner. Licensee required to make sworn statement, on or before December 1, showing whether or not any game animals have been killed by him, and if so the number and sex of each kind, time and place of killing, and name of guide present when killing was done.

Bag limits and possession: One deer, 1 elk, 1 sheep, a season; 4 sage hens, 8 geese, 15 other game birds

WYOMING—Continued

a day; possession limited to 15 game birds of which not more than 6 may be sage hens.

Interstate transportation: Export of all protected game prohibited; provided, game may be exported if properly tagged by a justice of the peace, fee 50 cents. Game tags issued under affidavit that game was lawfully killed, and if for edible portion, that it is not for sale. Not more than 50 ducks, 16 geese, 16 brant, 50 Wilson snipe, 30 in all of plovers and yellowlegs, or 50 in all of rails, coots, and gallinules may be exported by one person in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Person possessing game during close season in State must show lawful taking.

Sale: Sale of all game of State prohibited; provided, the sale of game (except edible portion) is permitted when properly tagged. Justice of peace issues tags (fee, 50 cents), under affidavit that game was lawfully captured or killed. Sale of migratory birds prohibited.

⁸⁰ *Wyoming:* The State game and fish commission may suspend open season in any county or district of State on any species of game when threatened with extinction.

⁸¹ State game and fish commission may permit bull moose and buck antelope to be killed in certain sections, to be designated, from September 15 to October 31. Commissioner may issue not to exceed 100 permits for each species when authorized. Bull moose: Fees, resident citizen, \$50; nonresident or noncitizen, \$100; limit, 1 a season. Buck antelope: Fees, resident citizen, \$25; nonresident or noncitizen, \$50; limit, 1 a season.

Canada

The migratory birds convention act of August 29, 1917, as amended in 1919, and the regulations thereunder, promulgated by the Governor General in council are similar to the migratory bird treaty act and regulations in that they give effect to and conform with the provisions of the treaty between the United States and Great Britain for the protection of migratory birds in the United States and Canada.⁸²

Canada also has a general law prohibiting export of deer in the carcass or parts thereof (except as to cured deer heads and hides of deer and except carcasses and parts of deer raised on private preserves); and wild turkey, quail, partridge, prairie fowl, and woodcock; but subject to Provincial laws and under a permit from the collector of customs, a nonresident licensee, on not more than two occasions during one calendar year, may export, during the open season in the Province where killed and within 15 days thereafter, not more than the whole or parts of one moose and of three deer not being moose, legally shot by him for sport and not for gain or hire; provided, however, that a nonresident licensee may export from Yukon Territory in one year the hides and heads of not more than 2 moose, 4 caribou, and 4 deer not being moose or caribou. Such licensee, at any port of export, may make an export entry in duplicate of such deer or parts thereof upon subscribing before the collector of customs a declaration to be annexed to said export entry, producing his license or permit for shooting the deer to the collector of customs who shall indorse thereon a description of the quantity and parts entered for exportation, and thereupon, if satisfied as to the identity of the sportsman and that the exportation is not prohibited, may issue his permit under the seal of the customs house for the export of the deer or parts thereof, which permit must accompany the shipment. The ports of export are Halifax and Yarmouth, Nova Scotia; McAdams Junction, St. John, and St. Stephens, New Brunswick; Montreal, Quebec, Sherbrooke, Beebe Junction, and St. Armand, Quebec; Bridgeburg, Brockville, Kingston, Ottawa, Port Arthur, Prescott, Niagara Falls, Sarnia, Saulte Ste. Marie, Toronto, and Windsor, Ontario; Emerson, Manitoba; North Portal, Saskatchewan; Coutts, Alberta; Kingsgate and Waneta, British Columbia; White Horse, Yukon Territory; and all other customs ports and outports on the frontier of the United States; and such others as the minister of customs may designate.

⁸² *Canada:* Full text of the regulations, as amended, will be found in separate publication (see footnote 2, p. 4).

ALBERTA

Dates inclusive

Open seasons: ⁶³	
Deer, moose, caribou (must have horns at least 4 inches long).....	Nov. 1-Dec. 14. ⁶⁴
Sheep (male), goat (must have horns at least 4 inches long).....	Sept. 1-Oct. 31.
Grouse, partridge, prairie chicken, ptarmigan.....	Oct. 1-Oct. 31.
Hungarian partridge (south Battle River only—north, no open season).....	Sept. 15-Nov. 15.
Duck, goose, brant, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs, rail, coot, gallinule.....	Sept. 15-Dec. 14.

No open season: Elk or wapiti, buffalo; females of deer, moose, sheep, young of all big game with horns less than 4 inches in length, antelope (1925); pheasant, dove, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses:⁶⁴ Nonresident: General, \$25; bird, \$5. Resident: Big game, \$1; birds, \$2.25; not required of farmer or member of family residing with him on farm nor of residents residing north of fifty-fifth parallel; guide, \$2.50 (guide may not act for more than three persons on any trip). Special license: Nonresident, \$25; resident, \$2.50 (issued to holders of general licenses and authorizes taking of deer, moose, and caribou in Rocky Mountain Forest Reserves of Alberta, September 1 to October 31, inclusive). Taxidermist, \$5. Issued by minister of agriculture.

Bag limits: Deer, moose, caribou, sheep, goat, 1 of each species a season; grouse, partridge, prairie chicken, ptarmigan, 10 a day, 50 a season; Hungarian partridge, 15 a day, 75 a season; 30 ducks a day, 200 a season; 15 geese, 15 brant, 25 in all of rails and coots, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day.

Export: Export of all protected game prohibited, except that minister of agriculture may grant permits for export of game at the rate of \$5 for each head of big game and \$1 per dozen for game birds. The holder of a general nonresident license may take with him out of Province as trophies, heads, skins, and hoofs of big game legally killed by him. Any person may export mounted or branded heads at a fee of \$1 for each head. Export of migratory birds prohibited during close season.

Sale: Sale of the flesh of all game prohibited. Heads of big game before being sold must be stamped by minister of agriculture at fee of \$5 for elk, caribou, moose, sheep; and \$2 each for deer and goat.

⁶³ Alberta: Resident north of 55th parallel, when necessary to provide food for his family, may kill big game (other than buffalo and elk) and scoters.

⁶⁴ Deer, moose, and caribou (big game must have horns at least 4 inches long), open season under special license in Rocky Mountain Forest Reserves of Alberta, September 1 to October 31, inclusive (see Hunting Licenses).

BRITISH COLUMBIA⁶⁵

Open seasons:	Dates inclusive
Duck, goose, brant, rail, coot, gallinule, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs (1924-25):	
Northern and Eastern District ⁶⁶	Sept. 15-Dec. 30.
Western District ⁶⁶ —north of fifty-third parallel.....	Sept. 13-Dec. 28.
Duck, rail, coot, and gallinule: Western District—south of fifty-third parallel.....	Oct. 15-Jan. 29.
Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs: Western district—south of fifty-third parallel.....	Oct. 1-Jan. 15.
Goose, brant: Western District—south of fifty-third parallel.....	Nov. 8-Feb. 23.

BRITISH COLUMBIA—Continued

No open season: Buffalo, elk, young of deer and goat, and females and young of moose, caribou, and sheep; swans, wood duck, band-tailed pigeons, little brown and sandhill cranes, auklets, auks, bitterns, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, puffins, shearwaters, terns, and all shorebirds (except Wilson snipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: General, \$25 and \$25 additional for each grizzly bear, moose, sheep, wapiti, or caribou, \$15 additional for each black or brown bear, mountain goat, or mule deer, and \$5 additional for every deer or any other species shot by him; bear, January 1-July 1, \$25; angling, season \$5, or \$1 per day up to five days; British subject, birds \$5 per week. Resident and members of Army, Navy, air forces, or militia on duty in Province: Deer and birds, \$2.50; big game and birds, \$5. Big game, birds, and trapping, \$10 (holder must report within two months after expiration of license number of big game or fur animals taken); guide, \$5, taxidermist, \$5. Issued by warden or any person authorized by him.

No fee required of farmer holding over 10 acres of land or member of family for license to hunt birds and deer on land on which he resides. Free license granted to prospector under certain conditions upon production of free miner's certificate. No license issued to person under 18 without written consent of parent or guardian, and then to hunt with firearms only under supervision of licensed adult. Unlawful to hunt on cultivated, cleared, or inclosed land without owner's consent.

Badge to be worn by licensee. Firearms not to be carried without license.

Bag limits and possession: Twenty ducks a day, 150 a season; 10 geese a day, 50 a season; 10 brant a day, 50 a season; 25 in all of rail and coot, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. (Limits on other species of game fixed by regulations of lieutenant governor in council.) Game may be possessed for two weeks after close of open season. Unlawful for a dealer in skins to possess the skin of any wapiti (elk) or deer.

Export: Export prohibited of all protected game except under permit of the Game Conservation Board.

Sale: Sale of migratory game birds prohibited and of all other game, except under regulations of lieutenant governor in council.

⁶⁵ British Columbia: Regulations prescribing seasons, bag limits, and restrictions on the sale of big game and upland game birds for season 1924-25 are adopted by the lieutenant governor in council. Full information may be had from the secretary, Game Conservation Board, Vancouver, British Columbia.

⁶⁶ For definition of districts, see Regulation 2 (footnote No. 2, p. 4).

MANITOBA

Open seasons:	Dates inclusive
Deer, moose, caribou, or reindeer (males).....	Dec. 1-Dec. 10.
Ptarmigan.....	Oct. 1-Oct. 20.
Prairie chicken, partridge, ruffed grouse.....	Oct. 15-Oct. 22.
Duck (in portion of Province north of fifty-third parallel, Sept. 1-Nov. 30), goose, brant, rail, coot, Wilson snipe.....	Sept. 15-Nov. 30.

No open season: Bison or buffalo, elk or wapiti, antelope or cabri, females and young of big game, dove, quail, pheasant, Hungarian partridge, introduced game bird (1927); swans, wood duck, eider ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe).

MANITOBA—Continued

Hunting licenses: Nonresident alien, big game, \$25; birds, \$25. Nonresident British, big game, \$15; birds, \$10. Resident, big game, \$5; birds, \$2. Issued by minister of agriculture. Hunting prohibited on inclosed or cultivated land or land covered by buildings or water, without consent of owner. No license required of farmers or members of family to hunt on farm on which they reside. Holder of resident bird license required, on or before December 15, to return license with sworn statement that he has not violated the act.

Bag limits and possession: One in all of deer, moose, and caribou a season; 15 ptarmigan a day, 50 a season; prairie chicken, 35 a season; partridge or ruffed grouse, 25 a season; 20 ducks a day in September, 40 a day in October and November, 200 a season; 10 geese, 15 brant, 25 in all of rails, and coots, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. Possession of ptarmigan, prairie chicken, partridge, and grouse allowed for 10 days, and of ducks for four months after close of hunting season. Venison for private use may be possessed at any time on proof of legal killing. Heads and hides of big game legally taken, within or without Province, may be possessed at any time.

Export: Export prohibited of all protected game except under permit issued by department of agriculture. No permit may be issued for export of ptarmigan, prairie chicken, partridge, grouse, geese, ducks, or entire carcass of any moose, caribou, or deer; provided, nonresident licensee under permit issued free may export carcass of moose, caribou, or deer, and not more than 50 geese and 50 ducks killed by him. (No duck may be exported before October 1.) Export of migratory birds prohibited during close season.

Sale: Sale of all protected game prohibited except heads and hides of big game.

Miscellaneous: Hunters must wear complete outer suit and cap of white material.

NEW BRUNSWICK

Open seasons: *Dates inclusive*
Deer (see exception)..... Sept. 15–Nov. 14.

Exception: On Grand Manan, Campobello,⁸⁷

and Deer Islands..... No open season.

Bull moose..... Oct. 1–Nov. 30.

Duck, goose, brant, rail, coot, gallinule (see exception)..... Sept. 15–Dec. 31.

Exception: Islands in the

Grand Manan group..... Oct. 15–Jan. 31.

Woodcock, jacksnipe or Wilson snipe..... Oct. 1–Nov. 30.

Black-bellied and golden plovers, yellowlegs..... Aug. 15–Nov. 30.

No open season: Caribou (Oct. 1, 1927); calf under 3 years and cow moose; pheasant; partridge;⁸⁸ swans, wood duck, eider ducks, auks, bitterns, fulmars, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and fishing licenses: Nonresident: General, \$50; bird, \$25; trout, \$10; salmon, \$25. Resident: Big game, \$3; taxidermist, \$1; guide, \$1; camp help, \$1. Big game license not issued to person under 18. Issued by minister of lands and mines and authorized vendors. Nonresident licensee must have registered guide, and not more than 2 hunters may accompany one guide.

Bag limits and possession: Two deer, 1 moose (lumber camp limited to 2 moose and 4 deer) a season; 6 partridges a day, 20 a season; 25 ducks, 15 geese; 15 brant, 25 in all of rails, coot, gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. Game may be kept for personal use in cold storage during close season under permit.

Export: Export of all game prohibited, except under license tags and permit from minister of lands and mines.

NEW BRUNSWICK—Continued

Sale: Sale of all game prohibited, except that a licensed hunter may sell moose or deer which he has lawfully killed. Keepers of hotels, inns, etc., may serve game during open season and 15 days thereafter. Hides and skins of animals may be sold under license by nonresidents or aliens, fee, \$25; and residents, fee, \$5.

⁸⁷ *New Brunswick:* Minister of lands and mines may issue license (fee, \$1) to resident of Grand Manan or Campobello Island to take one deer, Dec. 1–Dec. 10.

⁸⁸ Season on partridge may be opened by order in council.

NORTHWEST TERRITORIES⁸⁹

Open seasons: *Dates inclusive*

Deer and moose (males only),
mountain goat..... Sept. 1–Apr. 1.
Mountain sheep, caribou..... (Aug. 1–Oct. 1;
Dec. 1–Apr. 1.

Partridge, prairie chicken,
ptarmigan, and other
grouse..... Sept. 1–Jan. 1.

Duck, goose, brant, rail, coot,
gallinule, Wilson snipe,
black-bellied and golden
plovers, yellowlegs..... Sept. 1–Dec. 14

No open season: Buffalo or bison; musk-ox, wapiti or elk, does, cow moose; females of caribou, sheep, and goat with young, and young of any such animals; swan (1928); wood duck. Hunting or trapping prohibited on Victoria and Banks Islands; auks, bitterns, little brown and sandhill cranes, fulmars, grebes, guillemots, gulls, jaegers, loons, murrets, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting and trapping licenses: General: Nonresident, \$150; nonresident British subject, \$75; resident, \$2; birds, nonresident, \$5; trading or trafficking in game: Nonresident, \$300; nonresident British subject, \$150; resident, \$5. Issued by director of Northwest Territories. Native-born Indians, Eskimos, or half-breed bona fide residents of Northwest Territories may hunt without a license.

Bag limits: Two bull moose, 2 male deer, 4 caribou; mountain sheep, 2 of any species, 3 in all; mountain goat, 2 of any species a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coot, and gallinules, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day.

Export: Export of the meat of any game prohibited.

Sale: Sale of game illegally taken prohibited.

⁸⁹ *Northwest Territories* means the northwest territories formerly known as Rupert's Land and the Northwestern Territory (except such portions thereof as are included in the Provinces of Ontario, Quebec, Manitoba, Saskatchewan, and Alberta and the Yukon Territory), together with all British territories and possessions in North America and all islands adjacent thereto not included within any Province, except the Colony of Newfoundland and its dependencies.

⁹⁰ Indians, Eskimos, bona fide inhabitants, explorers, and surveyors may take game, except buffalo, musk-ox, or elk, and the eggs of birds when actually needing them to prevent starvation.

NOVA SCOTIA

Open seasons: *Dates inclusive*

Deer, male (except in Counties
of Cape Breton, Inverness,
and Victoria, no open season)
.....⁹¹ Oct. 10–Oct. 31.

Moose, bulls (except on Cape
Breton Island, no open season)
.....⁹¹ Oct. 1–Nov. 15.

Hare, rabbit..... Nov. 1–Feb. 28.

Stuffed grouse (birch partridge)
..... Oct. 1–Oct. 31.

NOVA SCOTIA—Continued

Open seasons—Continued *Dates inclusive*
Duck, goose, brant, rail, coot, gallinule (see exceptions)..... Sept. 15-Dec. 31.

Exceptions: Goose, brant, in Shelburne and Queens Counties (only persons holding license from minister)..... Nov. 1-Feb. 14.

Duck, rail, in Yarmouth and Shelburne Counties..... Oct. 15-Jan. 31.

Woodcock, Wilson snipe or jacksnipe..... Oct. 1-Nov. 30.

Black-bellied and golden plovers, yellowlegs..... Aug. 15-Nov. 30.

No open season: Caribou (1890); females and young of deer and moose; Canada grouse (spruce partridge), pheasant; swans, wood duck, eider ducks, auks, bitterns, fulmars, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident: All game, \$40; birds and small game, except woodcock and snipe, \$15, nonresident paying taxes equal to license fee, \$10; military or naval officer stationed in Province, \$5; resident, alien, \$10. Resident: Big game, \$2; guide, \$2. Taxidermist, \$5. Issued by commissioner of forests and game and municipal clerks.

Bag limits and possession: One deer, 1 moose a season; 5 ruffed grouse, 25 ducks, 15 geese, 15 brant, 25 in all of rails, coot, and gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. The green hide or fresh meat of big game may be possessed as follows: Moose, October 1 to November 20; deer, October 16 to November 3.

Export: Export prohibited of all protected game, except that holder of nonresident general license may ship out of Province under license tag 1 moose lawfully shot by himself.

Sale: Sale of deer, moose, caribou, pheasant, blackcock, capercaillie, Canada grouse (spruce partridge), chukar partridge, ruffed grouse, and all migratory game birds, prohibited. Rabbits may be sold November 4 to February 1 and any game bird other than those above mentioned, during the open season, with the exception of the first three days.

²¹ *Nova Scotia:* Every person killing a deer or moose must, within 10 days, make a written and signed report to the commissioner of forests and game showing his address, when and where such animal was killed, and its sex.

ONTARIO

Open seasons: ²² *Dates inclusive*

Deer, bull moose, caribou, north of main line Canadian Government Railway, between Quebec and Manitoba boundary lines..... Sept. 15-Nov. 15.

South of Canadian Government Railway to French and Mattawa Rivers..... Oct. 25-Nov. 30.

South of French and Mattawa Rivers (see exception)..... Nov. 5-Nov. 20.

Exception: Deer in St. Edmund, Lussay, Eastnor, Albemarle, and Greenock Townships, Bruce County, no open season.

Hare..... Unprotected.
Ruffed grouse or partridge..... Oct. 15-Nov. 20.
Woodcock..... Sept. 15-Oct. 15.

Duck, goose, brant, black-bellied and golden plovers, yellowlegs, jacksnipe or Wilson snipe, rail, coot, gallinule (see exception)..... Sept. 1-Dec. 15.

Exception: Eider duck, north of Quebec, Cochrane, Winnipeg line of Canadian Nat. Ry., only..... Sept. 1-Dec. 15.

ONTARIO—Continued

No open season: Cow and calf moose and young of moose and caribou under 1 year of age; black or gray squirrels, quail, pheasant or prairie fowl, wild turkey; dove, swans, wood duck, auks, bitterns; little brown, sandhill, and whooping cranes; gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, terns, and all shorebirds (except woodcock, Wilson snipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident: General, \$41; game birds and rabbits, \$21. Resident: Moose and caribou, \$5.50; deer, \$3.50; camp license, \$3.50 (allows 1 deer to 6 persons for food in camp). Farmers living upon and tilling their own land in districts of Haliburton, Muskoka, Parry Sound, Nipissing, and Manitoulin and that part of Province lying north and west thereof may kill during open season 1 deer for own use without license. Guide, \$2. Issued by department of game and fisheries.

Bag limits and possession: One deer, 1 bull moose, 1 caribou a season; 10 ruffed grouse or partridge a season; 25 ducks a day, 200 a season; 15 geese, 15 brant, 25 in all of rails, coot, and gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. Two or more persons hunting together under license may kill an average of 1 deer each. Possession permitted during open season and until March 31 following of all game except migratory birds.

Export: The export of all wild game animals and birds is prohibited; provided, 1 deer, 1 bull moose, reindeer, or caribou, and 100 ducks may be exported under nonresident hunting license if shipping coupon and, if required, affidavit of lawful killing be attached and contents of packages be open to view. Minister may issue permit for the export of game, dead or alive, at any time, except migratory birds, during close season.

Sale: Sale of migratory game birds, quail, and ruffed grouse or partridge prohibited. All other native game may be sold during the open season by the person killing it, and by dealers during open season and until the following January 1, under license; hotels, restaurants, and clubs under license may sell during closed season to March 31.

²² *Ontario:* Lieutenant governor in council may alter the current close season on any game animal or game bird whose numbers have diminished.

PRINCE EDWARD ISLAND

Open seasons: *Dates inclusive*

Hare, rabbit..... Nov. 1-Feb. 1.

Partridge (closed in even, open in odd years)..... Oct. 15, 1925.

Duck, goose, brant, rail, coot, gallinule..... Sept. 1-Dec. 14.

Woodcock, jacksnipe or Wilson snipe..... Sept. 15-Nov. 30.

Black-bellied and golden plovers, yellowlegs..... Aug. 15-Nov. 30.

No open season: Swans, wood duck, eider ducks, bitterns, little brown crane, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$15; if applicant pays taxes on real estate valued at \$325, fee \$5; sons and brothers of residents returning for visit, \$2.50; guest, \$2. Issued by game inspectors and tax collectors. Hunting on inclosed lands without permission of owner prohibited.

Bag limits: Twenty-five ducks, 15 geese, 15 brant, 25 in all of rails, coot, and gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day.

Export: Export prohibited of all game except goose and brant; provided, nonresident licensee may carry out of Province 12 birds killed by himself if tagged and carried open to view. Export of migratory birds prohibited during close season.

Sale: Game lawfully killed (except migratory birds) may be sold.

* QUEBEC

Open seasons:	Dates inclusive
Moose (see exception).....	Sept. 10-Dec. 31.
Exception: South of St. Lawrence River.....	Sept. 20-Dec. 31.
Caribou.....	Sept. 20-Dec. 31.
Deer.....	Sept. 1-Nov. 30.
Hare.....	Oct. 1-Jan. 31.
Bear.....	Aug. 20-June 30.
Birch or swamp partridge.....	Sept. 1-Dec. 14.
White partridge or ptarmigan.....	Nov. 1-Jan. 31.
Duck, goose, brant, rail, coot, gallinule, woodcock, jack-snipe or Wilson snipe, black-bellied and golden plovers, yellowlegs.....	Sept. 1-Dec. 15.

No open season: Cow moose, young of deer, moose, and caribou, swans, wood duck, elder ducks, auks, bitterns, fulmars, gannet, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shorebirds (except woodcock, Wilson snipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident: General, \$25 (members of incorporated hunting clubs, \$10). Resident, \$2 (not required of resident British subject hunting for own use); resident special, \$5 (3 deer and 3 caribou additional to limit). Issued by minister of colonization.

Bag limits and possession: Two deer, 1 moose, 2 caribou a season; 2 caribou and 3 deer under special resident license. Twenty-five ducks, 15 geese, 15 brant, 25 in all of rails, coot, and gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. Game lawfully killed may be possessed until 15 days after close of open season.

Export: Export of moose, caribou, and deer, or parts thereof, prohibited except under tags attached to nonresident license not later than 15 days after close of season; export of migratory birds prohibited during close season. Big game lawfully taken and coming from without Province may be transported under permit issued by minister of colonization (fee not to exceed \$5). Unlawful to export deer, moose, and caribou skins without payment of royalties prescribed by lieutenant governor in council.

Sale: Sale of birch or spruce partridge prohibited until October 15, 1925. Game lawfully taken may be sold from the third day of open season to and including the fifteenth day after expiration of open season, except that sale of migratory birds is prohibited during close season. Licensed hotels, restaurants, and clubs may serve game lawfully taken, except birch or spruce partridge.

SASKATCHEWAN

Open seasons:	Dates inclusive
Deer, moose (males only), caribou (see exception).....	Nov. 15-Dec. 14.
Exception: South of Township 35.....	No open season.
Ruffed grouse (partridge), sharp-tailed grouse, Canada grouse (spruce grouse), prairie chicken (pinnated grouse), ptarmigan.....	Oct. 1-Oct. 31.
Duck, goose, brant, rail, coot, gallinule, Wilson snipe or jacksnipe, black-bellied and golden plovers, yellowlegs.....	Sept. 15-Dec. 31.

No open season: Antelope, buffalo, elk, and females of big game other than caribou, and young of big game under one year of age.⁶⁴ Sage grouse, European, gray, or Hungarian partridge; swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident: Big game, \$25; birds, \$15; nonresident domiciled in Canada, birds, \$5; issued by minister of agriculture. Resident: Big game, \$5; birds, \$1.25. Issued by minister or agent. Bird license not required of residents hunting on land outside city, town, village, or hamlet on which they are actually

SASKATCHEWAN—Continued

domiciled. No license issued to person under 16 without written consent of parent or guardian. Big-game hunters must wear white suit and cap. Hunting prohibited on inclosed lands without consent. Taxidermist, \$5.

Bag limits and possession: One moose, 2 deer, 2 caribou, but not more than 2 in all of big game animals a season; ruffed grouse, sharp-tailed grouse, Canada grouse, prairie chicken, ptarmigan, 10 in all a day, 30 in all a season; 30 in all of ducks, geese, and brant a day, 200 a season; 25 in all of rail and coot, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day. Game birds may be kept in licensed storage from September 16 to March 1 and flesh of big game from December 1 to April 1 if tagged with number and kind of game, name of depositor, and number of his hunting license. Licensed hunters must report number of big game and game birds killed.

Export: Export of all protected game prohibited; provided, nonresident licensee on leaving Province may take with him during open season personally under his license coupons and permit big game and 100 game birds legally killed. Export of migratory birds prohibited during close season. Minister may issue permits to export deer (fee, \$2 per head) or other big game (fee, \$5 per head), hides of big game (fee, \$1 each), flesh of big game (fee, \$1 each 20 pounds or less), birds (except grouse family) (fee, \$1 per dozen, limits, 1 dozen grouse, 5 dozen waterfowl, per season). No permit may be issued for the entire carcass of a moose, elk, caribou, or other deer, and no person may export in one season more than 60 ducks or geese or 12 prairie chickens or other grouse.

Sale: Sale of the flesh of all protected game prohibited.

⁶³ Saskatchewan: Lieutenant governor in council may extend close seasons over current year, within limits, on petition of six game guardians.

⁶⁴ Male moose having horns less than 6 inches in length deemed to be under one year of age.

YUKON

Open seasons:	Dates inclusive
Deer, moose, caribou, sheep, goat (males only).....	Aug. 1-Mar. 1.
Partridge, prairie chicken, grouse, ptarmigan, pheasant.....	Sept. 1-Mar. 15.
Duck, goose, brant, rail, coot, gallinule, Wilson snipe, or jacksnipe, black-bellied and golden plovers, yellowlegs.....	Sept. 1-Dec. 14.

No open season: Elk or wapiti, musk-ox, bison or buffalo, and females of other big game; swans, cranes, grebes, gulls, jaegers, loons, terns, and all shorebirds (except Wilson snipe or jacksnipe, black-bellied and golden plovers, and yellowlegs).

Hunting licenses: Nonresident, \$100 (permits the killing of 1 moose, 2 deer, 2 caribou, 1 sheep, and 1 goat); licensee in addition may kill 1 moose, 2 deer, 2 caribou, 1 sheep, and 1 goat, but must pay a fee of \$25 for each additional animal so taken. Resident, \$25 (special license authorizing the killing of male moose and male caribou over 1 year of age at any time for food supplies in the Territory); licensee must make annual returns. Resident: Chief guide, \$20; assistant guide, \$10; camp helper, \$5. Issued by commissioner or game guardian.

Bag limits: (For limits on big game to a nonresident, see "Hunting licenses.") Six caribou, 6 deer, 2 moose, 2 sheep, 2 goats a season; 25 ducks, 15 geese, 15 brant, 25 in all of rail, coot, and gallinules, 10 woodcock, 25 Wilson snipe, and 15 in all of plovers and yellowlegs a day.

Export: Export of migratory birds prohibited during close season. Upon affidavit of lawful killing, commissioner may issue permit to export game. Export of raw hide of moose or caribou prohibited except under permit. Trophies, including head, hide, and hoofs, of big game lawfully killed by nonresident may be exported under his license and certificate of game guardian.

YUKON—Continued

Sale: Deer, moose, caribou, sheep, and goats lawfully taken may be sold during the open season and 60 days thereafter. Male moose and male caribou over 1 year of age killed by a resident under special license may be sold at any time for food upon obtaining certificate of lawful killing from a game guardian. License (fee, \$10) required to purchase and traffic in the flesh of moose or caribou.

Colony of Newfoundland

Open seasons:

Dates inclusive

Caribou (except in a special region near Grand Lake, no open season).....	Aug. 1-Sept. 30; Oct. 21-Jan. 31.
Hare, rabbit.....	Sept. 20-Jan. 1. ⁹⁰
Ptarmigan, willow grouse or partridge, plovers, curlew, snipe, or "other wild or migratory birds (except wild geese and crows, unprotected)".....	Sept. 20-Jan. 1.

No open season: Elk, moose.

Hunting and fishing licenses: Nonresident: Caribou, \$51; fish (salmon and sea trout), \$10.50. Guide, nonresident, \$50; resident, free.

Caribou licenses issued by game and inland fisheries board, stipendiary magistrate, or justice of peace.

YUKON—Continued

Licensee must make annual returns. Sale of migratory birds prohibited during close season.

⁹⁰ Yukon: Indians, explorers, surveyors, prospectors, miners, and travelers in need of food may take game during close season. Commissioner in council may alter seasons.

Unlicensed guides not to be employed. Guide may not conduct party of more than three.

Bag limits: Three caribou (stags) a season by nonresident licensee; 2 stags, 1 doe, by resident.

Export: Export for sale prohibited of caribou, partridge, willow or other grouse; provided, licensee may export three stag caribou under hunting license and export permit (fee, 50 cents); resident may export antlers, head, or skin of caribou under export permit, but not, in either case, for sale.

Sale: Caribou may be sold from August 1 to January 1; ptarmigan and willow grouse taken in open season and in possession of seller on January 1, may be sold until January 15; other birds may be sold during open season.

⁹⁰ Newfoundland: Hare or rabbit may also be taken with trap or snare until March 31.

Mexico

MEXICO

Open seasons: ^{90a}

Dates inclusive

Upland plover.....	Sept. 1-Sept. 30.
Wilson snipe, or jacksnipe.....	Nov. 1-Feb. 28.
Lesser yellowlegs.....	Aug. 16-Sept. 15.
Other shorebirds, duck, goose, swan.....	Oct. 16-Feb. 28.
White-winged and other doves.....	Sept. 16-Nov. 15.
Pigeon and armadillo.....	Oct. 1-Dec. 31.
Wild turkey, curassow, cojilite, and peccary.....	Sept. 1-Dec. 31.
White-tailed deer of tablelands.....	Nov. 1-Jan. 31.
White-tailed deer of Gulf and Pacific slopes.....	July 1-Oct. 31.
Brocket or forest deer in hot country.....	May 1-June 30.
Bear.....	Sept. 1-Oct. 31.
Alligator.....	Mar. 1-Sept. 30.

No open season: Mule deer, antelope in Chihuahua and Coahuila (1926); antelope elsewhere and mountain sheep (1923). White heron (1926). Mule deer on Cerros Island (1928). Quail and partridge (1926). Gulls, insectivorous and song birds, manatee, and the young and females of all animals.

Licenses: ^{90a} Resident: To export game, 10 pesos; to hunt for sale, 30 pesos. Nonresident: Alien, export, 25 pesos; commercial, 120 pesos.

Export: Export of quail prohibited for two years (1928).

^{90a} Mexico: Secretary of Agriculture and Interior has authority to establish seasons and issue licenses.

LOWER CALIFORNIA—NORTHERN DISTRICT

Open seasons: ⁹⁷

Dates inclusive

Deer (males only) (see No open season).....	Aug. 1-Sept. 30.
Mountain quail.....	Oct. 1-Dec. 31.
Other quail, ducks.....	Oct. 1-Jan. 31.
Doves.....	Oct. 1-Nov. 30.
Rabbits and squirrels.....	Unprotected.

No open season: Females and young of deer, and all deer on Cerros Island; hunting of deer also prohibited within 20 kilometers of the coast. Antelope and mountain sheep (1933); white herons (1927).

Licenses: Big game, fee, \$10; small game, fee, \$10. Issued by governor. Applicant for license must state the model, number, and caliber of shotgun or rifle to be used in hunting.

Bag limits: One male deer a season; 8 mountain quail a day, 25 a week; 15 other quail a day, 50 a week; 20 ducks a day, 50 a week; 5 white-winged and 12 other doves a day, 15 white-winged and 25 other doves a week.

Export: Export of quail prohibited.

⁹⁷ Lower California: Seasons and other restrictions subject to modification or suspension by governor at any time when deemed necessary.

ORDER: PERMITTING THE KILLING OF BOBOLINKS, COMMONLY KNOWN AS REEDBIRDS OR RICE BIRDS, WHICH HAVE BECOME SERIOUSLY INJURIOUS TO AGRICULTURAL INTERESTS

[Issued January 17, 1919]

Information having been furnished the Secretary of Agriculture that bobolinks, commonly known as reedbirds or rice birds, have become seriously injurious to the rice crops of North Carolina, South Carolina, Georgia, and Florida, and an investigation having been duly and regularly made pursuant to law, and it having been determined by the Secretary of Agriculture that said birds have become, under extraordinary conditions, seriously injurious to the rice crops in said States and that the injuries so inflicted by them can not adequately be controlled in the communities immediately affected, and that they should therefore be killed in the manner, during the seasons, and in the States and District hereinafter provided,

Now, therefore, I, D. F. Houston, Secretary of Agriculture, pursuant to authority in me vested by the migratory bird treaty act of July 3, 1918, and in conformity with Regulation 10 of the Migratory Bird Treaty Act Regulations approved and proclaimed July 31, 1918, do order that until further notice persons may kill by shooting, bobolinks, commonly known as reedbirds or rice birds, from half an hour before sunrise to sunset, from September 1 to October 30, inclusive, in the States of New Jersey, Pennsylvania, Delaware, and Maryland, and the District of Columbia, and from August 16 to November 15, inclusive, in the States of Virginia, North Carolina, South Carolina, Georgia, and Florida, but the birds so killed shall not be sold, offered for sale, or shipped for purposes of sale, or be wantonly wasted or destroyed, but they may be used for food purposes by the persons killing them, and they may be transported to hospitals and charitable institutions for use as food.

D. F. HOUSTON, Secretary of Agriculture.

IMPORTED GAME AND GAME RAISED IN CAPTIVITY

Regulations adopted pursuant to the provisions of the Federal migratory-bird treaty act and the Canadian migratory-birds convention act, which give effect to the migratory-bird treaty in the United States and Canada, respectively, are designed to permit and encourage the propagation and sale of migratory waterfowl. Many States now have laws in practical conformity with the Federal regulations on waterfowl and also permit other species of game to be raised in captivity and sold under permit. The business of game farming when properly conducted has proved profitable, and the demand for game raised in captivity has been greatly increased, for the reason that the sale of migratory birds is prohibited throughout the United States and most of Canada under Federal and Dominion laws, and the sale of practically all species of game is prohibited under State laws.

The Department of Agriculture, acting in conjunction with State game officials and sportsmen, aids so far as possible in establishing the game-breeding industry by preparing drafts of suitable laws to be enacted by the States, issuing permits to breeders to obtain wild migratory waterfowl and their eggs, and otherwise advising where stock may be obtained. The department does not distribute breeding stock or eggs, but in proper cases and under suitable restrictions permits may be issued to assist legitimate enterprises in the conduct of the business of game farming.

The possession, sale, and transportation of imported game and game raised in captivity is also regulated in most States by State laws, which are covered in the following summary:

Federal regulations:⁶⁶ Under permit from the Secretary of Agriculture, and subject to the provisions of State laws, live migratory waterfowl raised in captivity may be possessed, sold, and transported at any time for propagation, and such birds may be killed in any manner (except that they may be killed by shooting only during the open season for waterfowl in the State where killed) and the carcasses with heads and feet attached may be sold and transported at any time to any person for actual consumption, or to the keeper of a hotel, restaurant, or boarding house, retail dealer in meat or game, or a club, for sale or service to their patrons, who may possess such carcasses for actual consumption without a Federal permit; provided, that no migratory waterfowl killed by shooting shall be bought or sold unless each bird before attaining the age of four weeks shall have had removed from the web of one foot a portion thereof in the form of a V for identification purposes.

Permits also are issued under proper restrictions for the capture of a reasonable number of wild migratory waterfowl and the taking of their eggs to enable persons desiring to engage in the business to acquire the nucleus of a breeding stock or to improve the strain of birds on hand, but such wild birds may be sold and possessed only for propagation and may not be killed or sold for food.

Alabama: Commissioner of game and fisheries may issue a permit (fee, \$1) to capture or export not more than 10 pairs of each species of game birds for propagating purposes.

Arizona: State game warden may issue permit to take, export, or import game or birds for propagating purposes; and may also issue permit to retain in captivity not more than four abandoned young of big game which applicant has rescued.

Arkansas: The commission may establish rules governing propagation of game in captivity and authorizing the sale or export of such game under permit.

California: Game raised in captivity under breeder's license (fee, \$2.50) may be sold for breeding purposes, and under regulations of commission may be sold for food if tagged (fee, 3 cents a tag). All game raised in captivity (except deer) must be killed otherwise than by shooting. Permits may also be issued to capture, possess, or transport wild game animals and game birds for propagating purposes. Shipments by parcel post are prohibited. Pheasants and domesticated reindeer may be imported and sold under regulations of commission.

Colorado: Game raised in licensed private parks, if accompanied by an invoice, and game (except migratory birds other than migratory waterfowl) raised in captivity in conformity with Federal regulations—No. 8) brought into State by licensed importer, if shipping invoice is indorsed to purchaser, may be sold and transported. Commissioner may issue permit to capture or import game for propagating purposes.

Connecticut: Game birds and quadrupeds raised in preserve under license (fee, \$2) may be sold and transported, if tagged, under regulations of commissioners of fisheries and game. Game legally taken and transported from another State

Connecticut—Continued

or country which does not prohibit its sale or export may be sold under regulations of the board.

Permit required to import game which is protected in the State.

Delaware: Pheasants and Hungarian partridges may be possessed and sold for propagating purposes. Board, by permit (fee, \$1), may authorize any person to capture, possess, and transport not more than 10 pairs of each species of game or birds for propagating purposes.

District of Columbia: Hungarian partridge, English, Mongolian, Chinese, and ring-necked pheasants, and migratory waterfowl raised in captivity, in conformity with Federal regulations, may be possessed, sold, and transported.

Georgia: Registered breeder may possess, buy, sell, and transport game for propagation.

Idaho: Permit of State game warden required to take or keep waterfowl in captivity for decoy purposes. Under regulations of the State game warden, game may be propagated in private parks.

Illinois: Game raised in captivity under a breeder's license (fee, \$5) may be possessed, sold, and transported for food or propagating purposes.

Indiana: Birds and animals raised in captivity may be kept, killed, sold, or transported under certificate of inspection (fee, \$5) from the conservation commission, and game birds legally acquired may be possessed for breeding purposes under like certificates.

Iowa: Game birds raised in captivity under license (fee, \$2) may be sold for food or propagating purposes.

Kansas: Game raised in captivity under permit (fee, \$2) may be sold and transported, and under permit and regulations of warden wild animals and birds and the eggs of birds may be taken for propagating purposes.

Kentucky: Game birds and game animals raised in captivity under permit may be sold and transported, but all carcasses must be tagged.

Louisiana: Game raised in captivity under license (fee, \$5) may be sold and transported for food, stocking, or breeding purposes, but all carcasses must be tagged. Traffic prohibited in birds killed by shooting. Wild birds or mammals may be brought into State for liberation, and game may be exported for educational, scientific, or propagating purposes, under permit from commissioner.

Maine: Game raised in captivity under breeder's license (fee, \$2) may be killed, sold, and transported, and live game may be captured or exported for breeding and advertising purposes, under regulations and permit of commissioner.

Maryland: Elk and imported and native deer raised in preserve under license (fee, \$5) may be sold and transported. (In Allegany and Garrett Counties white-tailed deer native to the State must be branded 3 months prior to killing.) Chinese, English, or ring-necked pheasants raised in captivity may be sold for propagating and restocking purposes, but they may be killed only from November 10 to January 1 on premises where raised, and by means other than shooting. In Washington County game animals and birds reared in licensed preserves (fee, \$10) may be sold for propagation only.

⁶⁶ See Federal regulation 8 for full details and requirements (footnote 2, p. 4).

Massachusetts: Under regulations of the division of fisheries and game, deer, elk, pheasants, quail, and European or gray partridges raised in captivity under license (no fee), may be sold for propagation, and killed and sold for food purposes, if tagged; and licensed dealers may sell unplucked bodies of pheasant, Scotch grouse, European black game, European or gray partridge, red-legged partridge, and Egyptian or migratory quail imported from without the United States, if tagged, and deer, moose, caribou, and elk lawfully killed and coming from without the State, if tagged by warden of State or country where procured. State tag fees, 5 cents each. Hares and rabbits may be sold during the open season if secured and imported from a country where their sale is not prohibited. Waterfowl may be reared in captivity and sold under Federal regulations (No. 8).²⁴

Michigan: Deer, elk, pheasants, and wild ducks raised in captivity under license (fee, \$5) may be sold and transported for food, breeding, or stocking purposes. Carcasses of such game must be tagged (tags, 5 cents each). Ducks killed by shooting²⁵ (except under direct supervision of a deputy warden) may not be sold or disposed of. Licensed dealers may sell unplucked carcasses of pheasants of all species, Scotch grouse, European black game, red-legged partridge, Egyptian quail, European red deer, fallow deer, roebuck, and reindeer lawfully imported from another State or country if tagged on arrival in State. Licensed retail dealer, club, hotel, restaurant, or boarding house may sell portion of said imported game or game raised in captivity, if tagged, to patron or customer for actual consumption or use.

Minnesota: Game raised in captivity under license (fee, \$1) may be sold alive for propagating purposes, and may be killed, sold, and transported under regulations of commissioner. No fee required to raise game birds for domestic use or as pets. Under regulations of the commissioner, wild animals and birds and the eggs of birds may be taken for breeding purposes.

Missouri: Deer, elk, and other protected game raised in captivity under license (fee, \$5) may be transported and sold under regulations of commissioner. Export (except of quail) for propagating purposes allowed under permit.

Montana: Game raised in private preserves under license (fee, \$5) may be killed, sold, and transported. Commissioner may authorize the capture under permit of wild animals and birds for propagation, but no such animal or its progeny may be sold for a period of three years after its capture.

Nebraska: Game animals and birds raised in captivity under license (fee, \$1) may be sold for propagation, and killed and sold for food purposes if tagged. Keeper of hotel, boarding house, restaurant, club, or retail dealer in meats under license (fee, \$5) may sell tagged game to patron or customer for actual consumption, but tags must remain on carcasses until consumed.

Nevada: Game raised under license (fee, \$10) may be sold or shipped under invoice.

New Hampshire: Game raised in captivity under license (fee, \$2) may be sold and transported, if tagged, under regulations of commissioner. Game (except ruffed grouse) imported from without the United States, if tagged and marked to show kind and number, name and address of consignor and consignee, initial point of billing, and destination, may be exported unaccompanied by the owner.

New Jersey: Mallard, wood, and black ducks, Canada geese, English and Mongolian pheasants, quail, ruffed grouse, deer, rabbits, and squirrels raised in preserves under license (fee, \$5) may be possessed and sold for propagation, and may be sold for food or exported for sale if tagged (tag fee, 5 cents). The unplucked carcasses of Scotch grouse, European black grouse, European black plover, red-legged partridge, and Egyptian quail coming from a foreign country, if tagged by State authorities, may be sold for food purposes.

New Mexico: Game raised in licensed preserves may be exported or sold under invoice, if the number of animals or birds in the park at the time the license is secured is not thereby reduced. State warden may issue permit (fee, \$1.25) to retain in captivity not more than 4 abandoned young of big game which applicant has rescued. Holder of a hunting license, under permit from State warden, may capture and export game or birds for propagating purposes. Game (except migratory birds other than waterfowl raised in captivity in conformity with Federal regulations²⁶) coming from without State may be possessed and sold by a hotel, restaurant, café, boarding house, or dealer under a permit good for not more than 30 days.

New York: Elk, white-tailed deer, European red deer, fallow deer, Japanese deer, roebuck, pheasants, Canada and Hutchins geese, and mallard and black ducks raised in captivity may be sold for breeding purposes, and may be killed and sold or exported if tagged. Such ducks and geese may be killed by shooting during the open season, but when so killed may not be sold unless marked and tagged as required by the commission.²⁷ Varying hares and cottontail rabbits raised in captivity under license (fee, \$5) if tagged, may be sold for food purposes during close season, under regulations of the commission. Licensed breeders in States having laws similar to the game-breeding law of New York may, under license (fee, \$5) and cost of inspection, ship into State domesticated American elk, white-tailed deer, European red deer, fallow deer, roebuck, pheasants, Canada and Hutchins geese, and mallard and black ducks, which, if tagged, may be sold under regulations of the commission.

The unplucked carcasses of timonin, pheasants, Scotch grouse, European gray-legged partridge, Norwegian ptarmigan, Norwegian grouse, and Egyptian quail, and species or subspecies not native to State, and carcasses of European red deer, fallow deer, and roebuck imported from without the United States may be sold under license if tagged. No restrictions on reindeer.

North Carolina: There are no State laws relating to game raised in captivity, but several counties have laws on this subject. These laws are too varied to make it practicable to publish them. In those counties under the jurisdiction of the Audubon Society, Raleigh, N. C., the society may issue permits authorizing ruffed grouse and wild turkeys to be exported for propagation.

North Dakota: Game may be kept in captivity under permit of board.

Ohio: Ring-necked, Mongolian, or Chinese pheasants and mallard and black ducks raised in captivity under a breeder's license (fee, \$5) may be sold and transported for food or propagating purposes; carcasses of such birds must be tagged. No pheasant, mallard, or black duck raised in captivity may be killed by shooting except during the open season, and no mallard or black duck killed by shooting may be bought or sold unless it shall have had a well-defined V-shaped section removed from the web of one foot before attaining the age of four weeks.

Deer, squirrels, and rabbits legally taken or acquired may be possessed in inclosures as pets.

Oklahoma: Game raised under license (fee, \$2) may be sold and transported for propagation and for food, if tagged, during season prescribed by commissioner.

Oregon: Game birds and animals raised in captivity under permit (fee, \$2) may be exported or sold for propagating, restocking, or food purposes; carcasses must be tagged (fee, 5 cents). Written permit from State warden, showing kind of game and names and addresses of consignor and consignee, must be attached to each shipment.

Game animals and birds coming from without the United States and game taken in a State where it may be sold, may be sold and transported under permit and tag of State warden, but the only migratory birds that may be sold are waterfowl²⁸ in regulations.

²⁴ See Federal Regulation 8 for full details and requirements (footnote 2, p. 4).

²⁵ See Canadian Regulation 12 (footnote 2, p. 4).

Pennsylvania: Game breeder's certificate required, fee, \$1; bond, \$500. Game raised in captivity may be sold or transported within the State.

Rhode Island: Game raised in captivity under permit may be sold for propagation, under regulations of commissioners. Game lawfully killed and exported may be brought into State under permit, but such game may not be sold.

South Carolina: Birds and animals legally taken may be kept in possession for propagating purposes. The Federal regulations have been adopted as the State law with respect to migratory birds.²⁸

South Dakota: Game raised in captivity under license may be exported or sold under written permission of State game warden.

Texas: Game animals and birds may be captured or imported for propagating purposes under permit of commissioner.

Utah: Game raised in private preserve under permit (no fee) of commissioner may be sold and transported, if tagged.

Vermont: Game raised in licensed private preserve, (fee, \$2) may be sold or exported for food or propagating purposes. Carcasses must be tagged.

Virginia: Game animals and birds raised under breeder's license (fee, \$25) may be disposed of for propagating or other purposes. Carcasses of game raised in captivity must be tagged (fees; wild turkeys, 10 cents; deer, bear, or elk, 50 cents; other birds and animals, 2 cents each). Proprietor of hotel or restaurant or dealer in game under a license (fee, \$5) may sell to guests or patrons deer, wild turkeys, quail, ruffed grouse, and waterfowl raised in captivity and may sell domesticated rabbits without a license.

Licensed game breeder, under permit and regulations of the commissioner may trap wild animals or birds for breeding purposes, but the animals or birds so taken shall not be sold or otherwise disposed of.

Washington: Game animals and birds raised in captivity under license (fee, \$10) may be sold and transported for propagation or for food, if tagged. Keeper of hotel, restaurant, boarding house, or club, and retail dealer in meats, under license (fee, \$5), may sell game raised in captivity, if tagged. Under permit from director of fisheries and game wild animals and birds may be captured on State game preserves or imported from without the State for propagating purposes.

Game animals and birds coming from without the State, if imported under license (fee, \$25), may be sold by keeper of hotel, restaurant, boarding house, or club, or by a retail dealer, under license (fee, \$5) and regulations of director of fisheries and game, but the only migratory birds that may be sold are waterfowl reared in domestication under Federal²⁹ and Canadian³⁰ regulations.

West Virginia: The owner may kill elk or deer kept in inclosure and may pursue and recapture, by killing or otherwise, elk which have escaped from his inclosure.

Wisconsin: Under permit and supervision of the commission wild animals and birds may be taken and transported for propagation within the State. Park boards allowed to ship, under permit of State conservation commissioner, live animals and game birds for park purposes.

Wyoming: Under permit (fee, \$5) and supervision of commission, game animals may be taken for propagation. Animals so taken may not be killed, sold, or disposed of for three years, but their natural increase may be sold, transported, and disposed of. Exchange of game animals and birds for liberation in State allowed under permit of State game commission.

Canadian regulations: The Canadian regulations, administered by the Commissioner of Canadian

National Parks, Ottawa, Canada, are similar to the provisions of the Federal regulations in respect to the propagation of migratory waterfowl, but apply to all migratory birds protected by the treaty; and all birds raised in captivity and intended for food purposes must be killed otherwise than by shooting, and each of such birds before it can be sold must bear a metal tag which may not be removed from the carcass. Under section 5 of the Canadian Customs Export Act (R. S. C., 1906, ch. 50) a person may export the carcass or parts thereof of a deer raised on his own land or on lands owned by a company or association of which he is a member, upon his making affidavit on face of export entry that the carcass, or parts thereof, is of a deer so raised.

Alberta: The minister of agriculture may authorize persons to possess, buy, sell, and export big game and game birds raised in captivity, and to capture big game and game birds for propagation. Permit fees fixed by lieutenant governor in council.

British Columbia: The game conservation board may authorize persons to possess, buy, sell, and export game animals and game birds raised in captivity, and to capture game animals and birds and collect eggs of birds for propagation. Permit required to import live animals or birds into the Province; permit fees fixed by lieutenant governor in council.

New Brunswick: The minister of lands and mines may authorize persons to possess, buy, sell, and export game raised in captivity, and to capture game for propagation. Permit fees fixed by minister.

Northwest Territories: The minister of the interior may authorize persons to possess, buy, sell, and export wild mammals and birds raised in captivity, and to capture wild mammals and birds and collect the eggs of birds for propagation.

Nova Scotia: The commissioner of forests and game may authorize persons to possess, buy, sell, and export wild mammals and birds raised in captivity, and to capture wild mammals and birds for propagation.

Ontario: The minister of game and fisheries may authorize persons to possess, buy, sell, and export game animals and birds raised in captivity, and to capture game animals and birds for propagation during close season. Imported game may be sold or exported under license.

Prince Edward Island: Domesticated wild geese and brant in captivity are deemed the personal property of the owner, and may be possessed, disposed of, and transported without reference to the provisions of the Provincial game act. Waterfowl and other migratory birds, however, are subject to the provisions of the migratory-birds convention act and regulations.³¹

Quebec: The minister may authorize game animals and birds lawfully taken during the open season to be retained in captivity.

Saskatchewan: The minister of agriculture may authorize persons to possess, buy, sell, and export big game and game birds raised in captivity, and to capture big game and game birds for propagation. All shipments must be tagged. Permit and tag fees fixed by minister.

Yukon: The gold commissioner may authorize persons to possess, buy, sell, and export game animals (except buffalo or bison) and birds raised in captivity, and to capture such animals and birds for propagation.

Newfoundland: The game and inland fisheries board may authorize persons to capture, possess, buy, sell, and export caribou for propagation.

Lower California (Northern District): The governor may authorize persons to capture, possess, buy, sell, and transport wild animals and birds for propagation.

²⁸ See Federal Regulation 8 (footnote 2, p. 4).

²⁹ See Canadian Regulation 12 (footnote 2, p. 4).

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1445

LAWS
RELATING TO
FUR ANIMALS
FOR THE SEASON
1924-25



THE information contained in this bulletin, the tenth annual publication on the subject, should be useful in promoting effective action on the part of trappers, members of the fur trade, and all others concerned to the important end of perpetuating one of the most valuable of our natural resources. Too large a proportion of the pelts coming to the raw-fur markets fall into the unprofitable class because they were taken when not prime, a waste which can be eliminated by cooperation between the fur trade and the trappers. The average quality of pelts would be much higher if laws made seasons shorter and uniform for areas having the same climatic conditions. If the fur business is to maintain its position among the great industries of the country the continued source of supply must be assured. The trappers and the furriers, as trustees, are jointly responsible for the permanence of our fur resources. The board of trade of the fur industry of the United States estimates the annual turnover in the fur business at \$400,000,000.

Washington, D. C.

September, 1924

OFFICIALS FROM WHOM COPIES OF LAWS RELATING TO FUR ANIMALS MAY BE OBTAINED

- Alabama:** Department of Game and Fisheries, Montgomery.
- Alaska:** Secretary of Agriculture, Washington, D. C., or Chief Alaska Game Warden, Juneau. (See footnote 3, p. 6.)
- Arizona:** State Game Warden, Phoenix.
- Arkansas:** Secretary, Game and Fish Commission, Little Rock.
- California:** Executive Officer, Fish and Game Commission, Forum Building, Sacramento.
- Colorado:** State Game and Fish Commissioner, Denver.
- Connecticut:** Superintendent of Fisheries and Game, Hartford.
- Delaware:** Chief Game Warden, Dover.
- District of Columbia:** Superintendent Metropolitan Police, Washington.
- Florida:** Secretary of State, Tallahassee.
- Georgia:** Game and Fish Commission, Atlanta.
- Hawaii:** Fish and Game Commission, Honolulu.
- Idaho:** Fish and Game Warden, Boise.
- Illinois:** Chief Game and Fish Warden, Springfield.
- Indiana:** Superintendent, Division of Fisheries and Game, State House, Indianapolis.
- Iowa:** State Fish and Game Warden, Des Moines.
- Kansas:** State Fish and Game Warden, Pratt.
- Kentucky:** Executive Agent, Game and Fish Commission, Frankfort.
- Louisiana:** Commissioner of Conservation, Court Building, New Orleans.
- Maine:** Commissioner of Inland Fisheries and Game, State House, Augusta.
- Maryland:** State Game Warden, 514 Munsey Building, Baltimore.
- Massachusetts:** Director, Division of Fisheries and Game, State House, Boston.
- Michigan:** Director, Department of Conservation, Lansing.
- Minnesota:** Game and Fish Commissioner, St. Paul.
- Mississippi:** Secretary of State, Jackson; and Sheriff or County Clerk.
- Missouri:** Game and Fish Commissioner, Jefferson City.
- Montana:** State Fish and Game Warden, Helena.
- Nebraska:** Chief Fish and Game Warden, Lincoln.
- Nevada:** Secretary, State Fish and Game Commission, Reno.
- New Hampshire:** Fish and Game Commissioner, Concord.
- New Jersey:** Secretary, Board of Fish and Game Commissioners, Trenton.
- New Mexico:** Game and Fish Warden, Santa Fe.
- New York:** Secretary, Conservation Commission, Albany.
- North Carolina:** Legislative Reference Librarian, Raleigh.
- North Dakota:** Secretary, Game and Fish Board, Minnewaukan.
- Ohio:** Chief Game Warden, Board of Agriculture, Columbus.
- Oklahoma:** State Game Warden, Oklahoma City.
- Oregon:** State Game Warden, Portland.
- Pennsylvania:** Executive Secretary, Board of Game Commissioners, Harrisburg.
- Rhode Island:** Chairman, Commissioners of Birds, Providence.
- South Carolina:** Chief Game Warden, Columbia.
- South Dakota:** State Game Warden, Pierre.
- Tennessee:** State Game and Fish Warden, Department of Agriculture, Nashville.
- Texas:** Game, Fish, and Oyster Commissioner, Austin.
- Utah:** Fish and Game Commissioner, Salt Lake City.
- Vermont:** Fish and Game Commissioner, Montpelier.
- Virginia:** Commissioner of Game and Inland Fisheries, Richmond.
- Washington:** Supervisor of Game and Game Fish, Box 384, Seattle.
- West Virginia:** Game and Fish Commission, Charleston; or Chief Game Protector, Buckhannon.
- Wisconsin:** State Conservation Commissioner, Madison.
- Wyoming:** State Game and Fish Commissioner, Cheyenne.
- Alberta:** Chief Game Guardian, Edmonton.
- British Columbia:** Secretary, Game Conservation Board, Vancouver.
- Manitoba:** Chief Game Guardian, Winnipeg.
- New Brunswick:** Chief Game and Fire Warden, Fredericton.
- Northwest Territories:** Director, Northwest Territories Branch, Department of the Interior, Ottawa, Ontario.
- Nova Scotia:** Commissioner of Forests and Game, Halifax.
- Ontario:** Superintendent of Game and Fisheries, Toronto.
- Prince Edward Island:** Deputy Federal Migratory Bird Officer, Charlottetown.
- Quebec:** General Superintendent of Fisheries and Game, Quebec.
- Saskatchewan:** Chief Game Guardian, Regina.
- Yukon:** Gold Commissioner, Dawson.
- Colony of Newfoundland:** Secretary, Game and Inland Fisheries Board, St. John.
- Mexico:** Director, Department of Agriculture and Development, City of Mexico.
- Lower California (Northern District):** Agent of the Secretary of Agriculture and Development, Tia Juana.

LAWS RELATING TO FUR ANIMALS FOR THE SEASON 1924-25

By FRANK G. ASHBROOK, *Biologist, in charge of Division of Fur Resources, and*
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Migratory Bird Treaty and Lacey Acts, Bureau of Biological Survey

INTRODUCTION

The fur resources of the United States have too long failed to receive the attention they deserve. The fur trader of the past was interested chiefly in the quantity of pelts he could collect, and the manufacturer has cared little about the origin of his raw materials. Europe was so long supreme in fur dressing that American furriers regarded the Old World as the essential source of their supplies, and when the dressing of furs became well established as an industry in the United States, the fur trade began to appreciate the fact that some of the more valuable fur animals had almost disappeared from our forests and streams, and that the production of a large part of the most important fine furs was confined to the Canadian Provinces. While the muskrat, the skunk, and, in places, a few other species are left in considerable numbers, the remnants of this once rich heritage in this country are fast dwindling under present-day conditions.

CAUSES OF FUR DEPLETION

The present shortage of furs is not due entirely to trapping or trapping methods. Much of it may be laid directly to the inadequacy of our laws, which in turn is due to lack of needed information on the part of farmers, trappers, and members of the fur trade, of legislative committees, and even of conservation commissions. The majority of the laws now on the statute books do little to prevent the decrease of fur animals in certain sections of the country. Indiscriminate felling of old forests, drainage of marshes, and other operations also have greatly reduced the extent of the natural fur-producing areas. The fact that many trappers have been permitted to ply their trade out of season and to gather pelts to the point of extermination of the fur bearers over great areas is another cause of our present shortage. Serious responsibility rests also on fur buyers and their agents, who by accepting at a price all skins offered and thus carrying to the markets unprime pelts, tempt the trapper to make a thorough clean-up along his trap lines. Seasons on fur animals have been frequently established without regard to the fact that they should be uniform for the same climatic zones in order that trapping may be done in all sections only when pelts are in prime condition. In fact, mountain and lowland areas within a single State frequently call for different legislation.

In practically every State revision of the fur laws on the basis of existing conditions and knowledge of the life habits and requirements of the various species would result in the utmost benefit to both the trapper and his quarry. It would not only afford the trapper more satisfactory returns for his annual catch but at the same time would conserve and foster an ever-increasing supply of breeding animals. Fur animals are hunted and trapped primarily for the fur they produce, not for sport or food, and there is only one brief season when the fur is in prime condition for harvesting.

UNPRIME PELTS

A frequent defect in the present laws for fur protection is that the open season is so long as to permit trapping before the pelts are prime in fall and after breeding is in progress in spring. That the seasons are not wisely determined is emphasized by the fact that far too many of the pelts coming to the raw-fur markets fall into the unprofitable class. These pelts would have been of real commercial value if taken at the proper season. A keener appreciation of conditions shown by studies of the habits, breeding seasons, and periods of prime fur for the various species on the part of fur buyers and their agents and those concerned with the framing

of laws and regulations governing trapping would have the result that a greatly increased quantity of pelts with fur of a superior quality would reach the markets, thus increasing the financial rewards to trappers for their efforts and at the same time allowing increased numbers of breeders to remain in the covers.

If the stock of fur animals is to be perpetuated as one of our natural resources uniform laws should be enacted to stop traffic in unprime skins, excepting, of course, the skins of animals classed as predatory. To protect their premises and property from damage is a right always to be carefully reserved to farmers in laws protecting wild animals.

Furs of many kinds were commonly taken in all sections of the country a few generations ago, but over great areas, with the depletion or extinction of certain of the more prized species, the most valuable fur bearers in the United States, from the standpoint of financial returns from the annual catch, are now the muskrat and the skunk. Muskrats reproduce rapidly, and consequently are more easily reestablished than most fur species. In spite of this, however, two and one-half months constitute a sufficiently long open season on muskrats, as the most valuable skins are those taken late in winter. Credit for present legislation protecting skunks is largely due to farmers, who recognize the usefulness of these animals in destroying noxious insects. Taking into consideration the prime condition of peltries and the economic status of these animals, an open season of more than three months' duration on them is not justifiable anywhere in the United States.

The greatest degree of cooperation and foresight on the part of everyone is essential if all species of fur bearers are to be retained permanently and the fur industry is not to be jeopardized. As wide a dissemination as possible by State game officials, State departments of agriculture, and State universities, of information concerning wild-life conservation will help bring about intelligent cooperation and a healthy sentiment on the part of all concerned in preserving this important natural resource.

REPORTS OF TRAPPERS

One of the most important features of present-day legislation on fur animals is that of requiring trappers to make annual reports of the number of each species taken. The trapping license, aside from its revenue-producing possibilities, affords the best known means for registration and identification of trappers, and its renewal from year to year should be conditioned upon the filing of satisfactory returns on the previous season's catch. The data to be obtained from these reports would provide a sound foundation for a survey of the annual kill and its relation to the breeding supply, or capital stock, and it is on such surveys that protective measures should be based. Given an intelligent estimate of the fur resources of a State, it becomes comparatively simple to frame legislation designed to permit the harvesting of the annual fur crop in its prime and most valuable condition and at the same time to build up and adequately safeguard the breeding stock.

RESTOCKING WITH FUR ANIMALS

There are many areas in Federal, State, and private bird and game preserves which could well be stocked or restocked with valuable species of fur animals, just as public and private waters are stocked with fish. The beneficial results which are enjoyed by the sportsmen and others who pursue, handle, or consume fish and game, due to the creation of Federal and State conservation bureaus and departments and the establishment of fish hatcheries, game preserves, and game farms, point to the wisdom of adopting similar measures for increasing the numbers of fur-bearing animals, especially when their importance is considered from the industrial and commercial standpoints. Precautions should be taken to see that the proposed restocking projects are so safeguarded as not to constitute a menace to crops or animal husbandry, but to utilize to the best advantage waste areas and other places unsuited to agriculture.

UNWISE DRAINAGE

Greater attention has been given in recent years to the need of preserving areas already stocked with wild life as being more productive and valuable in their original state than for agricultural purposes after drainage. Legislative committees are more and more seeing the advantage of referring proposed projects for the drainage of swamp areas to Federal or State authorities for recommendation before authorizing the operations.

An outstanding act of Congress, passed after a thorough consideration by wildlife conservation bodies and in accordance with their recommendations, was that creating the Upper Mississippi River Wild Life and Fish Refuge, on June 7, 1924. The act carries no appropriation for the purchase of lands, but authorizes an appropriation of \$1,500,000 to be made for the acquisition and setting aside of about 300,000 acres of swamp and low lands along the Mississippi River between Rock Island, Ill., and Wabasha, Minn. After these areas have been acquired by the Government, the Secretary of Agriculture will have jurisdiction with respect to fur-bearing animals, birds, and game, and the Secretary of Commerce will have jurisdiction over the fishes and other aquatic animal life.

FUR FARMING

As an attempt to supplement the fur supply and keep a steady flow of pelts coming to the fur trade, experiments in fur farming are deserving of encouragement. Available statistics indicate that there are approximately 1,200 fur farmers, or ranchers, engaged in the production of one or more species of fur-bearing animals in the United States and Alaska, and that on the majority of the farms blue and silver foxes are being raised. The total investment in the industry is estimated to be between \$12,000,000 and \$15,000,000. The Biological Survey maintains an experimental fur farm near Saratoga Springs, N. Y., and by investigations of diseases and parasites of fur animals and of management under controlled conditions seeks to give aid in some of the fundamentals of fur farming.

INTERSTATE SHIPMENTS OF PELTS

The United States Department of Agriculture, through the Biological Survey, is in position to aid State authorities in the prosecution of many violators of State conservation laws through the provisions of the Federal Lacey Act, which governs interstate shipments of wild animals. This legislation, enacted May 25, 1900, and amended and incorporated in the Criminal Code of the United States on March 4, 1909, prohibits delivery to any common carrier for transportation from one State to another of the dead bodies or parts thereof of wild animals, where such animals have been killed or shipped in violation of the laws of the State in which killed or from which shipped. It stands continually on guard as a supplement to State legislation for the protection of wild animals, and deserves careful study by all concerned in revising and framing State laws relating to fur animals, if the States are fully to avail themselves of its provisions. While this law carries no police power, and while the Federal wardens employed in its enforcement are not empowered to seize illegal shipments of furs or game animals, the department and the Federal wardens under its jurisdiction maintain close cooperation with the various States, and many thousands of dollars in penalties annually accrue to the States through the activities of Federal agencies operating under this law.

A violation of the Lacey Act is predicated upon a violation of the State law, but owing to the present status of State laws it is seldom possible to institute Federal prosecutions for illegal shipments of furs. The actual evidence of the illegal killing of fur animals is most difficult for the department to obtain as compared with the documentary evidence of shipments. For instance, frequently a State will protect beavers for an indefinite term or for a period of years, but will make no provision concerning the possession, sale, and shipment from the State of skins of such animals during the continuance of the close season.

In the enforcement of the provisions of the Lacey Act it has been found that most reputable raw fur houses are eager to cooperate to the fullest extent in the suppression of traffic in unprime and contraband skins. The most outstanding need in connection with traffic in beaver skins is a system of branding, perforating, or permanently marking those legally taken so that they may be satisfactorily identified and traced to the point of origin. With some such fairly uniform system in vogue in the beaver-producing States, reputable raw-fur dealers would be in position to refuse to handle contraband skins.

The system of tags, affidavits, and shipping permits in connection with the payment of royalties on furs in the various Provinces of Canada, appears to work to advantage in the suppression of illegal traffic in the skins of fur-bearing animals. Upon the payment of the royalty a duplicate form of tag is attached to the skin; half of it is surrendered for an export permit, while the stub remains attached to the skin as evidence that the royalty has been paid.

REVIEW OF LEGISLATION OF 1924

Two Federal laws were passed during the year which will be of consequence in the conservation of fur animals. One, already referred to, is the upper Mississippi River wild life and fish refuge bill, passed June 7, 1924; the other, passed the same day, by transferring jurisdiction of Alaska game to the Secretary of Agriculture, consolidates under the Biological Survey in one warden service, matters affecting both game and land fur animals in the Territory, thereby promoting the conservation of both in a more efficient single administration.

States holding legislative sessions since the last bulletin on the fur laws was issued were Alabama, Georgia,¹ Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, Rhode Island, South Carolina, and Virginia, and only fur laws of minor importance were enacted.

In Canada, changes were more general, but consisted primarily of slightly shortened or lengthened seasons on certain species, or increased or decreased fees for licenses to fur dealers or their agents.

The Department of Agriculture, by regulations, closed the season in Alaska to the trapping of martens, and continued the close season on beavers, while the commissioner of Yukon Territory, under authority granted him to adopt seasons on fur animals uniform with those in other Provinces and Territories contiguous to Yukon has, by regulation, closed the season for two years on martens in the Territory.

In order to safeguard hunting and trapping areas for native Indians, Eskimos, and half-breeds in the Northwest Territories, there have been set aside exclusively for them six areas, as follows: Victoria Island, 74,400 square miles; Banks Island, 26,400 square miles; Peel River Preserve, 3,300 square miles; Yellowknife Preserve, 70,000 square miles; Slave River Preserve, 2,200 square miles; and Backs River Preserve, 65,500 square miles.

SUMMARY OF LAWS

In some States legislation for the protection of fur animals has not progressed to the stage of stringent regulation, and this condition, together with the fact that such legislation is in the formative period, makes it often exceedingly difficult to determine what restrictions apply to transporting and marketing furs.

In stating the open seasons, the plan has been followed, as in the bulletin on the game laws,² to include *the first and last days thereof*. Statements regarding trapping on lands of another do not take into consideration the general trespass laws of the State. The bounty laws included relate to all animals and birds on which bounty is paid.

Federal Laws

Two Federal laws have a bearing on the fur industry of the United States—the Lacey Act, governing interstate commerce in wild animals, and the tariff act of September 21, 1922.

That part of the Lacey Act codified as section 242 of the Criminal Code (35 Stat. 1137) makes it unlawful to ship or transport “from any State, Territory, or District of the United States to any other State, Territory, or District thereof” the bodies or parts of bodies of any wild animals killed or shipped in violation of the law of the State, Territory, or District in which killed or from which shipped.

The tariff act of September 21, 1922, places a duty of 15 per cent ad valorem on all live wild animals shipped into the United States. This includes silver and black foxes, the skins of which, dressed or undressed, and manufactures thereof, are dutiable at 50 per cent ad valorem. Other furs dressed on the skin, not advanced further than dyeing, are dutiable at 25 per cent ad valorem. Raw furs and skins (except silver and black fox skins) are admitted free.

The regulations of the Department of Agriculture for the inspection, quarantine, and entry of foxes have been rescinded. Foxes may now be brought in at any port on presentation of the regular importation permits and payment of the duty imposed by the tariff act.

¹ The legislature of Georgia did not convene until late in June, and at the time of going to press no information was available concerning action taken on fur animals.

² Laws relating to game animals, including deer and other big game, rabbits, and squirrels, will be found in Farmers' Bulletin No. 1444, “Game Laws for the Season 1924-25.”

Laws of States

ALABAMA

Open seasons: ¹	Dates inclusive
Beaver, otter, bear, raccoon, opossum, mink, muskrat (trapping).....	Nov. 1-Mar. 1. ²
Prohibited methods: Unlawful to set traps in such manner as to endanger domestic stock.	
Licenses: Fee, \$15 for first trap and \$2.50 for each additional trap; issued by probate judges. Land-owners or landlords, tenants, and members of families may trap on own land during open season without license. Written permission required to trap on land of another.	
Possession and sale: Possession of the young of protected fur animals prohibited during close season. No restrictions on skins legally taken.	
Shipment and export: No restrictions on skins legally taken.	
Propagation: No legislation.	
Bounties: None paid.	

¹ Alabama; Owner may protect premises in any manner at any time from depredations of fur animals.

² Fur animals may be hunted with dog or gun: Sept. 1-Mar. 1.

ALASKA ²

Open seasons: ⁴	Dates inclusive
District 1: ⁴	
Muskrat.....	Dec. 16-Apr. 30.
Land otter, mink, weasel (ermine).....	Dec. 16-Mar. 31. ⁶
Red, cross, and silver foxes, lynx.....	Nov. 16-Feb. 15. ⁶
Blue fox (on Aleutian Islands Reservation only).....	Nov. 16-Feb. 15.
Black, cinnamon, and glacier bears.....	Sept. 1-June 30.
Wolf, wolverene.....	Unprotected.
District 2: ⁴	
Land otter, mink, weasel (ermine).....	Nov. 16-Mar. 31.
Muskrat (see exception).....	May 1-June 10.
Exception: South latitude 62° and west of longitude 141°, including waters tributary to Cook Inlet.....	Dec. 16-Apr. 30.
Foxes (blue foxes, north latitude 62° and on Bering Sea drainage south of latitude 62° to Bristol Bay only—elsewhere in district, no open season), lynx.....	Dec. 1-Mar. 31.
Black, cinnamon, and glacier bears.....	Sept. 1-June 30.
Wolf, wolverene.....	Unprotected.
District 3: ⁴	
Mink, land otter, weasel (ermine), fox, lynx.....	Nov. 16-Mar. 31.
Muskrat.....	May 1-June 10.
Black, cinnamon, and glacier bears, wolf, wolverene.....	Unprotected.

Throughout Territory:

Beaver, marten, sea otter.... No open season.

Prohibited methods: Unlawful to take or kill land fur animals with poison (except that poison may be used under official supervision for wolves, coyotes, and wolverenes) or by use of trap or device known as the "klips," steel bear trap, or any other trap with jaws having a spread exceeding 9 inches; to take protected fur animals with aid of dog, or foxes, minks, martens, land otters, weasels, muskrats, or beavers with aid of artificial light. Unlawful to destroy beaver houses or runways.

Licenses: Stationary fur buyer, \$15; traveling agent for stationary fur buyer, \$15; traveling fur buyer, \$100; issued by commissioner; fur buyer must also pay license tax on each pelt, as follows: Sea otter, \$3; silver fox, \$2; black fox, \$2.50; blue fox, 75 cents; polar, brown, and grizzly bear, and cross fox, 50 cents; black bear, beaver, marten, land otter, red and white fox, lynx, 25 cents; muskrat, weasel, 2 cents; pelt not specifically mentioned, 10 cents. No license required for

trapping, but trapper sending or removing furs from Territory must pay license tax on such skins and must keep record of all pelts taken and make annual report to commissioner on or before August 1, showing to whom and when sold or disposed of; and must pay tax on all pelts not sold to licensed fur trader in Territory.

Possession and sale: No restrictions on prime skins legally taken, except that it is unlawful to sell the heads or hides of moose, deer, caribou, sheep, goats, and brown bears. Blue-fox skins must be tagged or branded before being sold.

Shipment and export: No restrictions on prime skins legally taken, if license taxes are paid before transportation. Blue-fox skins (other than those raised on farms having a registered brand and branded with such brand), whether acquired in Territory or imported, must be tagged (fee, \$1.50) by commissioner. Shipments of furs consigned to points outside of Alaska must be reported to the Bureau of Biological Survey, Department of Agriculture, Washington, D. C.⁹

Propagation: No restrictions except that on the Aleutian Islands Reservation and certain other islands, permits to use the islands for fur farming and to trap animals for breeding purposes must be obtained from the Department of Agriculture. Fur farmer must obtain Territorial license, fee \$10, and pay Territorial license tax on each pelt sold. Issued by commissioner. Blue-fox farmer must register brand, fee \$10.

Bounties: Wolf, \$15; eagle, \$1.

² Alaska; Regulations relating to land fur animals may be obtained upon application to the Secretary of Agriculture, Washington, D. C., or to the chief Alaska game warden, Juneau, Alaska. For special information regarding sea otters and fur-seal fisheries and the Afognak Reservation, which are subject to special legislative and administrative control, application should be made to the Commissioner of Fisheries, Washington, D. C.

⁴ Unlawful to kill land fur animals when the fur is unprime; the killing of all land fur animals on Krusof and Partofshikof Islands and of all fur animals (except wolves) in drainage of Taku River from Taku Point to east end of face of Taku Glacier is prohibited.

⁵ District 1 includes the Aleutian Islands, Alaska Peninsula, and neighboring islands, and South-eastern Alaska, mainland and islands, from Yakutat Bay to Dixon Entrance.

⁶ Red, cross, and silver foxes, land otter, weasel (ermine), on Kodiak-Afognak Islands Group—Dark Island on the north, Marmot Island on the east, and Tugidak and Trinity Islands on the west and south—November 16-February 15.

⁷ District 2 includes the mainland and islands from Yakutat Bay, Gulf of Alaska, Iliamna Lake, and Bristol Bay, northward to the headwaters of the streams flowing into the Arctic Ocean north of the sixty-eighth parallel of north latitude.

⁸ District 3 includes the region drained by the streams entering the Arctic Ocean north of the sixty-eighth parallel of north latitude.

⁹ Blanks for reporting shipments by mail may be obtained from postmasters.

ARIZONA

Open seasons:	
Beaver.....	No open season. ¹⁰
All other fur and predatory animals.....	Unprotected. ¹¹

Prohibited methods: No restrictions.

Licenses: Fee, \$2.50; issued by warden, designated deputies, and clerks of boards of supervisors. License not required for trapping on own land, nor by persons under 18 years of age. Unlawful to disturb or remove traps of licensed trappers on public domain or on lands where they have permission to trap.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Miscellaneous: Unlawful to use fish or the flesh of any game bird or animal for trap bait.

ARIZONA—Continued

Propagation: Under permit from State game warden, fur-bearing and predatory animals may be kept for propagation, exhibition, or sale.

Bounties: Payment of bounties is optional with county board of supervisors.

¹⁰ Arizona: Expires Apr. 15, 1925.

¹¹ Mountain lion, wolf, fox, coyote, lynx, wildcat, skunk, or other obnoxious animals may be taken on State game preserves only under regulations of the State game warden. Owner may protect his premises from the depredations of predatory and fur animals at any time.

ARKANSAS

Open seasons: ¹² Dates inclusive

Bear, beaver, otter (see exceptions) Dec. 1, 1928.

Exceptions: Bear (15 days), Nov. 15-19, Dec. 26-30, and Jan. 10-14, inclusive, and beaver and otter, Nov. 15-Jan. 31, in Chicot, Desha, and Phillips Counties.¹³

Other fur animals (see exceptions) Dec. 1-Jan. 31.

Exceptions: In Faulkner and White Counties (except opossum, Oct. 1-Feb. 1) Nov. 1-Mar. 1.
In Chicot, Desha, and Phillips Counties¹³. Nov. 15-Jan. 31.
In Clay County. Oct. 1-Mar. 1.

Prohibited methods: No restrictions.

Bag limits: One bear a season.

Licenses: Trapping license, \$20 (only required for use of 12 or more traps). Hunting license required to kill bears: Resident, \$1.10; nonresident, \$15; dog, used in hunting bears, \$1.50; issued by State game and fish commission and circuit clerks.

County licenses for bear: Chicot County: Nonresident of State, \$50; resident of State, \$5.25; Desha County: Nonresident of State, \$50; resident of State, \$2.50; Phillips County: Nonresident of State, \$50; resident of State, \$2.50. Issued by circuit clerks. Licenses not required of residents under 16.

Possession and sale: Sale or possession of pelt taken in State prohibited except between December 1 and February 5. Sale or exchange of bears prohibited.

Shipment and export: No restrictions except on bears, the export of which is prohibited except by nonresident licensee under affidavit that the bear was legally taken and is not for sale.

Propagation: The fish and game commission is authorized to issue permits to breeders of game and fur animals under such regulations as it may prescribe.

Bounties: County courts may offer bounty on wolf, wildcat, or panther, and fix the amount of such bounty.

¹² Arkansas: Fur animals found destroying crops or poultry may be killed at any time.

¹³ In Chicot, Desha, and Phillips Counties fur animals may only be taken on own or leased land or land adjacent to cultivated crops.

CALIFORNIA

Open seasons: ¹⁴ Dates inclusive

Black or brown bear, ring-tail cat, coon, pine marten, fisher, wolverene, mink, skunk, river otter, fox. Oct. 15-Feb. 28.

Seal and sea lion (in Game District 19, no open season) Unprotected.

Beaver, otter. No open season.

Prohibited methods: Unlawful to use poisons or gun larger than No. 10 gauge in taking fur animals, or to dig, or smoke out skunks from dens.

Licenses: ¹⁴ Citizen, \$1; alien, \$2; issued by fish and game commission. License issued free to veterans of Civil War. Duplicate license issued only on affidavit of applicant that original has been lost or destroyed. License not required of

person under 18 years of age. Licensed trappers required to report catch before July 1. Licensee must exhibit license and furs to wardens or peace officers upon demand. Unlawful to disturb or remove traps of licensed trapper who is trapping on the public domain or on lands where he has permission to trap.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: Fur animals may be raised in captivity under regulations of the commissioners.

Bounties: Mountain lion, female, \$30; male, \$20; paid by fish and game commission. Boards of supervisors of counties may fix the rate and pay bounty on coyote, wildcat, fox, lynx, bear, or mountain lion. Many counties now pay a bounty on some of these animals, especially on coyotes.¹⁵

¹⁴ California: Written permission from board of fish and game commissioners required to trap or hunt predatory animals on State game refuges.

¹⁵ For information in regard to bounties in any county, applications should be made to the county clerk.

COLORADO

Open seasons:

Beaver..... No open season.¹⁶
All other fur animals..... Unprotected.¹⁶

Prohibited methods: No restrictions.

Licenses: Hunting license required to trap: Resident: General, \$5; limited, \$2 (for coyote, mountain lion, wolf, bobcat, lynx); nonresident, \$25; issued by commissioner, county clerks, and other agents. Unnaturalized resident not permitted to hunt, capture, or kill any wild bird or animal.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Miscellaneous: Use of game or fish for trap bait prohibited.

Propagation: No restrictions, except as to beaver and game animals.

Bounties: None paid by State since 1895. On petition of 50 freeholders, county commissioners may levy a tax to pay bounties on coyote, wolf, and mountain lion.

¹⁵ Colorado: The owner of property being damaged by beaver may be permitted to kill them under such regulations as may be provided concerning disposition of the skins by the State game and fish commissioner.

¹⁶ A permit from the State game and fish commissioner is necessary to take mountain lion, wolf, coyote, fox, lynx, wildcat, mink, marten, or wolverene on Colorado State Game Refuge.

CONNECTICUT

Open seasons: ¹⁷ Dates inclusive

Muskrat..... Nov. 1-Mar. 31.

Raccoon..... Oct. 8-Jan. 31.¹⁸

Fox, weasel..... Unprotected.

Skunk, otter, mink, and other

fur animals..... Nov. 1-Mar. 15.

Prohibited methods: Unlawful to trap with scented baits or to take animals with a snare or similar device, to use steel traps having more than a 6-inch spread of jaws, or any steel trap having teeth except for otter. Unlawful to disturb muskrat house or den or to hunt muskrats from sunset to sunrise. Traps must be visited at least once in 48 hours, and, on lands of another, must not be set in path, wood road, or specially prepared furrow. Owner or person using traps must have his name legibly stamped thereon.

Licenses: Hunting license required to trap: Resident, \$1.25; nonresident, \$10.25; issued by city or borough clerk. Person under 16 years of age denied a hunting license, but may obtain one for taking fur animals only. License not required of resident hunting or trapping on own land during open season. Permission of owner required to trap on lands of another. Licensee required to report number of animals trapped each season.

CONNECTICUT—Continued

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No restrictions on possession or sale of fur animals kept in captivity under license (fee, \$2).

Bounties: None paid.

¹⁷ *Connecticut:* Fox, skunk, raccoon, wildcat, mink, or weasel may be hunted or trapped on State game preserves only by superintendent of fisheries and game or persons designated by him. Fur animals may be killed at any time for protection of property.

¹⁸ Unlawful to trap raccoon prior to October 31.

DELAWARE

Open seasons: ¹⁹ *Dates inclusive*
Skunk, mink, otter, muskrat... Dec. 1-Mar. 10.²⁰
Fox..... Oct. 1-Apr. 30.
Raccoon, opossum..... Oct. 15-Jan. 15.

Prohibited methods: Unlawful to use pitfall, deadfall, scaffold, cage, snare, trap, net, pen, baited hook, or baited field or any other similar device, or any drug, poison, chemical, or explosive for taking animals protected by State laws, except muskrat, skunk, mink, and otter. Traps or other devices unlawfully set are subject to confiscation. Unlawful to destroy the nest, den, or lair of any animal protected by law. Unlawful to hunt, kill, take, or destroy any protected animal, except muskrat, skunk, mink, and otter, while the ground is covered with snow. Unlawful to shoot at or destroy any fox while it is being chased by a dog. Muskrats may not be taken during the time any flood or freshet may cause them to leave their usual places of shelter and protection, nor may they be shot at night, hunted with a dog, or taken by the method commonly known as "nailing."

Licenses: Hunting license required: Nonresident, \$10.50; resident, \$1.10 (not required in county of residence nor on own land); issued by commissioner. Permission of owner required to take or kill muskrats on land or marsh of another.

Possession and sale: Unlawful to sell fox or fox hide. No other restrictions.

Shipment and export: Unlawful to export fox or fox hide. No other restrictions.

Propagation: No restrictions, provided a permit is obtained from the chief game warden (fee, \$1). A limited number of wild fur or game animals for propagating purposes may be taken under permit.

Bounties: None paid.

¹⁹ *Delaware:* Owners may kill foxes at any time when destroying their poultry, and other fur animals may be killed at any time when destroying property.

²⁰ In New Castle County, on embanked meadows, muskrats may be taken from December 1 to March 20.

DISTRICT OF COLUMBIA

No legislation relating to fur animals.

FLORIDA

Open seasons: *Dates inclusive*
Beaver, otter..... Nov. 1-Jan. 31.
Other fur animals..... Unprotected.

Prohibited methods: Unlawful to use pitfall, deadfall, cage, snare, net, blind, pen, baited hook, or similar device, or drugs, poison, chemical, or explosive for injuring or capturing animals protected by law.

Licenses: Resident, \$1; nonresident or alien, \$25; issued by county judge. Permission of owner required to trap on inclosed land of another.

Possession and sale: No restrictions.
Shipment and export: No restrictions.
Propagation: No legislation.
Bounties: None paid.

GEORGIA

(Laws of 1924 not received)

Open seasons: *Dates inclusive*
Beaver, mink, otter, bear,²¹
skunk, muskrat,²² raccoon,
wildcat, ²¹ civet cat..... Nov. 20-Mar. 1.
Opossum..... Oct. 1-Feb. 1.
Fox (red, gray) (see exception) Sept. 1-Feb. 1.
Exception: Fox in Greene
County (with dogs only) Sept. 2-Jan. 31.

Licenses: Hunting license required to trap: Resident, State license, \$3; county license, \$1; nonresident State license, \$15; issued by commissioner or county warden. License not required to trap in militia district or on own or leased land during open season. Permission of owner required to trap on lands of another.

Possession and sale: Prohibited during close season.

Shipment and export: No restrictions.

Propagation: No restrictions on propagation of unprotected fur animals.

Bounties: None paid.

²¹ *Georgia:* Bear and wildcat may be hunted at any time for sport by holders of State hunting licenses, except that a license is not required in own militia district.

²² Fur animals destroying property may be killed at any time, and muskrats damaging cultivated or pasture lands or dams may be killed under permit from department of game and fish.

HAWAII

Hawaii has no wild animals valuable for fur. There are no restrictions on the propagation of fur animals except that mongooses and rabbits may not be kept or bred. Pet rabbits may be raised if kept in confinement.

IDAHO ²³

Open seasons: ²⁴ *Dates inclusive*
Beaver, marten, fisher, fox.... No open season.²⁵
Otter, mink, raccoon in Bene-
wah, Bonner, Boundary,
Kootenai, Latah, Lewis, Nez
Perce, and Shoshone Counties. Dec. 1-Mar. 1.
In rest of State..... No open season.
Muskrat in Benewah, Bonner,
Boundary, Kootenai, Latah,
Lewis, Nez Perce, and Sho-
shone Counties..... Dec. 1-Mar. 1.
In Mud Lake, Goose Lake,
and Gray's Lake..... Mar. 10-May 10.
In rest of State (except in
irrigated districts)..... No open season.
Other fur and predatory ani-
mals..... Unprotected.²⁴

Prohibited methods: Unlawful to destroy houses, dams, or other structures erected by fur animals.

Licenses: Resident, \$5; nonresident, \$25; alien, \$50; issued by warden, deputy, or authorized agent. Licensed trapper must make verified report at end of season of number and kind of fur caught, where sold, and the price received. Unlawful to destroy, disturb, or remove traps of licensed trapper.

Possession and sale: ²⁶ Skins of animals legally taken, within or without State, may be possessed or sold at any time. Unlawful to possess fur animals, or the hides thereof, on which there is no open season in the State, without permit from State game warden.

Shipment and export: No restrictions.

Miscellaneous: Unlawful to use flesh of any game animal for trap bait. Unlawful to destroy

IDAHO—Continued

houses, dams, or other structures erected by fur animals, except under permit of State warden.

Propagation: Permit from State warden required. Permittee must make verified yearly report showing number of animals kept in captivity, number sold, and number on hand.

Bounties: None paid.

²³ **Idaho:** State fish and game warden may close season in any locality on any species of fur-bearing animal threatened with extinction. Under permit of State warden, person may protect own premises from depredations of fur animals, except that bears doing damage may be destroyed without a permit.

²⁴ All trapping is prohibited on State game preserves, except that certain predatory animals may be killed thereon by deputy game wardens and persons authorized by State game warden.

²⁵ State game warden may grant permits to take beavers when doing damage to irrigation canals, crops, etc., or authorize deputy warden or State trapper to take such animals. Pelts of animals taken must be turned over to warden for sale, half the proceeds going to the permittee or person whose property is being damaged. Possession of beaver hides otherwise prohibited.

ILLINOIS

Open seasons: ²⁶	Dates inclusive
Otter, raccoon, mink, skunk, opossum, fox in northern zone.....	Nov. 1-Feb. 15.
In central zone.....	Nov. 15-Feb. 1.
In southern zone.....	Nov. 15-Jan. 15.
Muskrat in northern zone.....	Nov. 1-Mar. 31.
In central zone.....	Nov. 15-Mar. 15.
In southern zone.....	Nov. 15-Mar. 1.
Other fur animals.....	Unprotected.

Prohibited methods: Houses, dens, and den trees of fur animals protected, except otter and muskrat dens which obstruct public or private ditches or watercourses. Unlawful to use spear or similar device for hunting or taking fur-bearing animals or explosives, chemicals, or mechanical devices of any kind to drive them out of their burrows, dens, or houses. Use of automobile or vehicle propelled by mechanical power, or the lights thereof, or ferret in hunting or taking fur-bearing animal prohibited.

Licenses: Resident citizen, \$1; nonresident citizen, \$10.50; issued by county, city, or village clerk. License not required of landowners and tenants and members of families to trap during open season on the lands on which they reside. License not issued to person under 16 years of age without written consent of parent or guardian, nor to alien. Licensee, on or before April 15, must report all hides of fur animals taken, sold, shipped, or dealt in, together with names and addresses of persons to whom sold or shipped. Permission from owner, agent, or occupant required to trap on land of another.

Possession and sale: Possession of green hides of muskrats permitted only from November 1 to April 10, and of other protected fur animals from November 1 to February 25. No other restrictions on possession and sale.

Shipment and export: No restrictions on skins legally taken and possessed.

Propagation: Permit required to conduct a fur farm on which protected animals are reared; fee, \$2. Permit to breed and raise ferrets, fee, \$10.

Bounties: None paid by State; counties may pay bounty on groundhog and crow.

²⁶ **Illinois:** Northern zone comprises Henderson, Warren, Knox, Peoria, Woodford, Livingston, and Iroquois Counties and all counties north thereof; Southern zone comprises Madison, Bond, Fayette, Effingham, Jasper, and Crawford Counties and all counties south thereof; Central zone comprises all counties not included in the Northern or Southern zones.

INDIANA

Open seasons: ²⁷	Dates inclusive
Raccoon, fox, opossum, skunk, mink, muskrat.....	Nov. 10-Feb. 10.
Beaver, otter.....	No open season.

Prohibited methods: Traps set on land of another must be placed at least 18 inches within burrow or hollow log and must be visited at least once in each 36 hours. Muskrat houses protected except when obstructing ditches or watercourses. Unlawful to dig out fur-bearing animals or to chase them from their burrows by use of smoke, fumes, or chemicals.

Licenses: None required of residents; nonresident, \$15.50; issued by clerk circuit court. Written consent of owner, occupant, or lessee required to trap on land of another.

Possession and sale: Possession of fur animals or green hides prohibited during close season, except that fresh skins may be disposed of during first 5 days of close season.

Shipment and export: No restrictions on skins legally taken and possessed.

Propagation: All animals raised in captivity are considered domestic stock, and the owner may possess, sell, ship, transport, or otherwise dispose of them without regard to laws regulating the killing and disposition of wild animals. Fur animals, lawfully acquired, may be possessed for breeding purposes during close season. An inspection certificate, fee \$5, must be obtained from the Department of Conservation. Permit required to possess or harbor ferrets; fees, \$10 for each single ferret and \$5 for each additional one; issued by Conservation Department.

Bounties: Boards of county commissioners may pay bounty on wolf, fox, woodchuck, crow, owl, or hawk.

²⁷ **Indiana:** Protected fur animals may be killed at any time on one's own premises to protect property. The destruction of such animals, however, must be reported to the Department of Conservation within 5 days, and if hides are preserved, they must be sent to the department or arrangements made for their disposition.

IOWA

Open seasons: ²⁸	Dates inclusive
Beaver, mink, otter, muskrat.....	Nov. 15-Mar. 15.
Raccoon, skunk.....	Nov. 1-Jan. 31.
Other fur animals.....	Unprotected.

Prohibited methods: Use of poison prohibited; muskrat houses may not be injured or destroyed.

Licenses: Hunting license required to trap: Resident, \$1; nonresident or resident alien, \$10; issued by county auditor. License not issued to person under 18 years of age without written consent of parent or guardian. Owners of farm lands, their children, and tenants may trap on own land without license during open season. Permission of owner, occupant, or agent required to hunt or trap fur animals on cultivated or inclosed land of another.

Possession and sale: Possession and sale of protected fur animals or parts thereof, wherever taken, prohibited, except during open season and first 10 days of close season; provided that green hides in process of manufacture may be possessed at any time.

Shipment and export: Skins of protected fur animals legally taken may be exported during open season and first 10 days of close season.

Propagation: Breeder's permit, fee \$2, must be secured from State game warden to propagate protected fur animals.

Bounties: Boards of supervisors of counties may allow bounty on crow, groundhog, pocket gopher, or rattlesnake.

²⁸ **Iowa:** Fur animals may be destroyed at any time to protect public or private property.

KANSAS

Open seasons:	Dates inclusive
Muskrat, skunk, mink, raccoon, opossum, civet cat.....	Dec. 2-Feb. 28. ²⁹
Beaver, otter.....	No open season.
Other fur animals.....	Unprotected.

Prohibited methods: Ferrets, poisons, or use of smoke guns or other devices for forcing smoke, gas, or liquids into holes, dens, or runways, prohibited. Unlawful to destroy houses, dens, or runways of fur animals.

KANSAS—Continued

Licenses: Resident, \$1; issued by county clerk. Resident landowner and members of his family may hunt or trap on own land during open season without license. Trapping license not issued to nonresident or alien. Consent of owner or lessee required to hunt or kill wild animals on land of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: Quadrupeds raised in wholly inclosed preserve under license (fee \$2) may be sold at any time for breeding or stocking purposes. Shipments must be tagged to show number and kind of animals, number of breeder's license, and names and addresses of consignor and consignee, and be accompanied by permits from State warden. Licensee required to make annual report of number of animals in possession. Wild animals may be captured during open season and thereafter had in possession for breeding purposes, under rules and regulations of State warden.

Bounties: Coyote, \$1; wolf, \$5; crow, pocket gopher, 10 cents each; jack rabbit, 5 cents each; crow eggs, 1 cent each; paid by county.

²³ *Kansas:* Owner or legal occupant of land may destroy these animals at any time when they are destroying poultry or damaging other property.

KENTUCKY

Open seasons:³⁰ *Dates inclusive*
Beaver, mink, raccoon, fox, otter, opossum, skunk..... Nov. 15-Dec. 31.³¹
Other fur animals..... Unprotected.

Prohibited methods: Traps must be set 18 inches or more within a hole, cave, or hollow log, and must be visited within each 36 hours.

Licenses: None required. Written consent of owner or lessee required to trap on lands of another.

Possession and sale: Possession of green skins during close season prima facie evidence of unlawful taking.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation

Bounties: None paid.

³⁰ *Kentucky:* Fur animals may be killed at any time on one's premises to protect property.

³¹ *Raccoon, opossum, skunk, and mink* may also be taken with gun or dog from Oct. 1 to Feb. 15.

LOUISIANA

Open seasons: *Dates inclusive*
Bear³²..... Nov. 15-Jan. 31.
Muskrat, mink, otter, raccoon, skunk, opossum, civet cat.... Nov. 15-Feb. 15.³³

Beaver..... No open season.
Wolf, fox, wildcat, cougar..... Unprotected.³⁴

Prohibited methods: Unlawful to trap bear. Muskrat houses and nests, lairs, or dens of other fur animals protected.

Baglimits: One bear a day, 5 a season.

Licenses:³⁵ Resident, trapping (does not include privilege of hunting), \$1.25; issued by tax collector. Buyer, \$5; resident dealer, \$25; nonresident dealer, \$50; issued by commissioner. Nonresident dealer, \$30 (deer and bear); not permitted to trap.

Possession and sale: Skins legally taken may be possessed, sold, and shipped at any time.

Shipment and export: All shipments must bear tags furnished by commissioner; no furs nor alligator skin may be shipped out of State except by holder of a dealer's license or by a trapper shipping his own catch; export of bear prohibited, except under written permission of the commissioner.

Miscellaneous: Use of birds for trap bait prohibited.

Propagation: Fur animals for breeding purposes may not be captured except under restrictions specified in permits issued by department of conservation. Permit from the department is required to import wild quadrupeds into the State or to export from the State.

Bounties: None paid.

³² *Louisiana:* Bears may be killed at any time on one's own land when actually damaging property. Nonresidents coming into State to hunt bears required to report in writing to department of conservation on or before arrival at destination.

³³ Muskrats may be killed at any time when damaging any levee, and, under permit of department of conservation, to prevent damage to cultivated or pasture land; any fur animal may be killed by the owner of land upon which it is destroying property.

³⁴ Wolves, foxes, and wildcats hunted for sport may be taken in any manner at any time, and may be possessed by the lawful holder of a State hunting license.

MAINE

Open seasons:³⁵ *Dates inclusive*
Muskrat (see exceptions)..... Nov. 1-May 14.³⁶
Exceptions: In Somerset County..... Oct. 15-Apr. 30.
In Androscoggin, Cumberland, Knox, Lincoln, Sagadahoc, Waldo, and York Counties..... Dec. 1-Apr. 30.
In Kennebec County..... July 7, 1925.
Beaver..... No open season.³⁷
Bear, bobcat, Canada lynx (loup cervier), weasel..... Unprotected.
Raccoon,³⁸ skunk,³⁹ fox, and other fur animals..... Nov. 1-Feb. 23.³⁹

Prohibited methods: Unlawful to use snare, swivel, pivot, or set gun, or to put out poison for any animals. Traps may not be set within 25 feet of a muskrat or beaver house. Unlawful to dig out a fox den in close season. Owner's name and address must be either plainly stamped on the trap or on a metal tag firmly attached to it. A bear trap must be inclosed in a "hut," or surrounded with two strands of barbed wire, 5 yards distant from the trap, 4 and 5 feet, respectively, from the ground. Muskrat and beaver houses must not be disturbed.

Licenses: Required to trap fur animals (except bear and bobcat) in unorganized townships: Fee, \$10 (issued only to the holder of a hunting license); issued by commissioner. Licensee, on or before December 15 of each year, must make such report as the commissioner may require. Written consent of the owner or occupant must be obtained before setting traps on the lands of another in an organized county or incorporated place; such traps must be visited at least once in every 24 hours and any animals caught removed. Traps must be stamped or bear metal tag to show full name and address of trapper.

Special beaver-trapping license, good only in territory opened to beaver trapping by commissioner, fee, \$25.

Dealer in skins must be licensed (fee, State, \$25; county, \$2), and must keep a record of transactions and forward same to the commissioner of inland fisheries and game on or before December 20 of each year.

Possession and sale: Sale of beaver skins without seal of commissioner attached prohibited. No other restrictions on skins legally taken.

Shipment and export: Transportation of beaver skins without seal of commissioner attached prohibited. No other restrictions on skins legally taken.

Propagation: Permit required to raise fur animals (fee, \$2). Protected species may be taken under special permits for breeding purposes. No animals may be imported into the State without permit.

Bounties: Bobcat and Canada lynx (loup cervier), \$10 each; paid by State; claim to be made within five days after killing or return from trip on which killing was done. Bear, \$5 (\$10 in Washington

MAINE—Continued

and Penobscot Counties); paid by State; claim to be made within 10 days after killing.

³⁸ *Maine*: Any person may lawfully kill any wild animal, except beaver, found destroying his property.

³⁹ Special laws on muskrat, otter, fisher, and mink in certain localities in Cumberland, Kennebec, Oxford, Sagadahoc, and Washington Counties. For detailed information apply to Commissioner of Inland Fisheries and Game, Augusta.

⁴⁰ Commissioner of inland fisheries and game, upon written complaint of owner of timberland that beavers are doing substantial damage to his property, may declare special local open season on them (see "Licenses").

⁴¹ Raccoon after October 1, and skunks after October 15, may be hunted at night.

MARYLAND

Open seasons: *Dates inclusive*
 Otter, muskrat..... Jan. 1-Mar. 15.
 Other fur animals unprotected, except locally, as follows:

Raccoon:

In Allegany County, Sept. 1-Mar. 31; in Anne Arundel and Prince Georges Counties, Oct. 1-Jan. 31; ³⁹ in Baltimore County, Oct. 1-Feb. 28; ⁴⁰ in Carroll County, Oct. 1-Jan. 1; in Caroline County, Sept. 15-Mar. 31; in Dorchester County, Nov. 10-Mar. 15; in Frederick County, Nov. 15-Mar. 1; in Harford County, Nov. 1-Jan. 1; in Kent, Queen Anne, and Somerset Counties, Jan. 1-Mar. 31; in Montgomery County, Oct. 15-Jan. 14; in Wicomico and Worcester Counties, Oct. 1-Feb. 1.

Opossum:

In Allegany County, Sept. 1-Mar. 31; in Baltimore County, Oct. 1-Feb. 28; ⁴⁰ in Carroll County, Oct. 1-Jan. 1; in Frederick County, Nov. 15-Mar. 1; in Montgomery County, Oct. 15-Jan. 14; in Washington County, Dec. 1-Mar. 31; in Wicomico and Worcester Counties, Oct. 1-Feb. 1.

Mink: In Frederick County, Nov. 15-Mar. 1; in Washington County, Dec. 1-Mar. 31; in Worcester County, Dec. 15-Mar. 1.

Skunk: In Frederick and Washington Counties, unprotected.

Fox: In Frederick County, Nov. 15-Mar. 1; in Caroline ⁴¹ and Carroll ⁴² Counties, no open season; in Worcester County (chase with dogs), Sept. 1-Mar. 9.

All fur animals (except as above mentioned):

In Frederick County, Nov. 15-Mar. 1; ⁴³ in Harford County (trapping), Nov. 15-Dec. 24.

Prohibited methods: Unlawful to take or kill otter or muskrat in any manner, except by gigging or trapping; to dig for muskrat or in any manner molest or destroy any part of a muskrat house or den. County restrictions as follows:

Anne Arundel and Prince Georges Counties.—Unlawful to cut down tree to obtain a raccoon.

Baltimore, Carroll, and Harford Counties.—Unlawful to hunt raccoon and opossum in Baltimore and Carroll Counties and raccoon in Harford County when snow covers the ground, or to set steel trap for raccoon in Harford County.

Baltimore, Calvert, Carroll, Prince Georges, St. Marys, Wicomico, and Worcester Counties.—Unlawful to shoot fox while it is being pursued by dogs.

Wicomico and Worcester Counties.—Unlawful to take raccoon or opossum with steel trap or similar device.

Licenses: Hunting license required to trap: Resident, State, \$5.10; county, \$1.10; nonresident, \$10.50 (see \$5.10 for State license if applicant owns real estate in Maryland assessed at \$500; \$1.10 for county license in county where such real estate is located); issued by clerk of circuit court—in Baltimore City by clerk of court of common pleas. Licensees required to wear tag displayed on middle of back and to carry license on person. License not issued to person under 14 years of age without written request of parent or guardian.

Owners, tenants, and their children may hunt on own land during open season without license.

Written consent of owner required to trap on land of another in Cecil, Frederick, Washington, and Worcester Counties.

Possession and sale: Possession of green hides of otter or muskrat prohibited except from January 1 to March 25. No other restrictions on possession and sale of skins legally taken. County restrictions as follows:

Allegany and Baltimore Counties.—Possession of raccoon and opossum prohibited during close season.

Anne Arundel and Prince Georges Counties.—Possession of raccoon prohibited during close season.

Harford County.—Sale of raccoon for export from county prohibited.

Shipment and export: No restrictions on skins legally taken and possessed, except that raccoons may not be removed from Harford County.

Propagation: No legislation.

Bounties: A State bounty of 50 cents each on bird hawk, or chicken hawk, killed in State, paid from State game-protection fund.

Allegany County.—Wildcat, \$2; fox, \$1; hawk or hood owl, 50 cents.

Garrett County.—Wildcat, fox, \$2; weasel, 50 cents; paid by county commissioners.

³⁸ *Maryland: Anne Arundel and Prince Georges Counties.*—Raccoon may not be taken between sunrise and sunset.

⁴⁰ *Baltimore County.*—Unlawful to set traps, except from Nov. 10 to Dec. 20, for mink, weasel, skunk, raccoon, opossum, or fox. Permits to take certain predatory fur animals when destroying property may be obtained.

⁴¹ *Caroline County.*—Unlawful to kill a fox except by bounds in a hunt or when the fox is destroying poultry.

⁴² *Carroll County.*—Landowner or tenant may kill a fox on own land at any time, except when such fox is pursued by bounds followed by hunters.

⁴³ *Frederick County.*—Raccoons or opossums may be hunted with dogs at night at any time. Landowners may protect property from ravages of fur animals.

MASSACHUSETTS

Open seasons: *Dates inclusive*

Mink, otter, skunk, raccoon (see exception)..... Nov. 1-Mar. 1.

Exception: Raccoon may also be hunted with dog and gun during October.

Muskrat..... Nov. 1-Apr. 10.³⁹

Other fur animals..... Unprotected.

Prohibited methods: Unlawful to open, disturb, or destroy muskrat house or to set trap within 10 feet thereof. Traps must be marked legibly with owner's name and must be removed at end of open season. Poison may not be used to kill animals, except rats, woodchucks, or other pests on one's own premises. The use of steel traps with spread of over 6 inches and "choke" traps with greater opening than 6 inches is unlawful, as is also the use of snares or, except by landowner, of scented baits. Except as otherwise stated, fur animals may only be taken by shooting or trapping.

Bag limits: Twenty-five raccoon a season.

Licenses: Hunting license required to trap: Resident citizen, \$1.50; nonresident citizen, \$10; alien, \$15 (alien applicant must own real estate to the assessed value of \$500); issued by city or town clerks. License not issued to minors under 15 years of age, and those under 18 must apply in writing and furnish written consent of parent or guardian. License (fee, 25 cents) to trap quadrupeds, in discretion of issuing officer, may be issued to any citizen between the ages of 12 and 18. License not required of resident on own land used exclusively for agricultural purposes and on which he is actually domiciled. The following nonresidents pay a fee of \$1.50: Members of incorporated game clubs owning real estate assessed at not less than \$500 for each member and which were organized prior to 1907; owners, or their minor children over 18 years of age, of real estate assessed at not less than \$500; or nonresidents

MASSACHUSETTS—Continued

invited (for not more than four days) by members of incorporated clubs for hunting foxes. Trappers must report catch to director on or before January 10 each year.

Written consent of owners required to trap on improved or posted land of another. Traps must be visited at least once in 24 hours. Animals may be removed from traps on Sunday, but traps may not be set or reset on such day.

Possession and sale: No restrictions on skins legally taken during open season.

Shipment and export: No restrictions on skins legally taken during open season.

Miscellaneous: Introduction of fox or raccoon in Dukes County prohibited.

Propagation: May be permitted under regulations of division of fisheries and game.

Bounties: Seal, \$2 (by Commonwealth); wildcat or lynx, \$5; paid by town, but refunded by county.

⁴⁴ *Massachusetts:* Fur animals unprotected in Dukes and Nantucket Counties. Muskrats may be taken after March 1 with trap only.

MICHIGAN

Open seasons: ⁴⁵ *Dates inclusive*
Beaver..... No open season.⁴⁶

Otter, mink, fisher, marten, raccoon, skunk, muskrat..... Nov. 1-Mar. 31.

Bear, wolf, coyote, fox, lynx, wildcat..... Unprotected.

Prohibited methods: Unlawful to use spears, explosives, chemicals, mechanical devices, or smokers to drive animals from their holes or homes; to destroy, disturb, or molest any beaver, skunk, or muskrat houses or holes; to shoot muskrats except with a .22-caliber rifle; or to set a trap within 6 feet of a muskrat house or hole.

Licenses: Resident, \$1; nonresident, \$10; issued by county clerk. A hunting license also permits the holder to trap fur-bearing animals, except beaver. Resident citizens and their minor children under 17 years of age may hunt or trap during open season on own inclosed lands upon which they live, without a license. License to hunt or trap on other lands issued to minors over 12 and under 17 on application of parents or guardian, but such licensed minors while hunting or trapping must be accompanied by parent or guardian. Alien prohibited from hunting or taking any wild animals in State.

Possession and sale: Possession of the carcass or skin of fur animals killed in close season prohibited.

Shipment and export: No restrictions on skins legally taken, possessed, or tagged.

Propagation: Annual license (fee, \$5) required to engage in raising fur animals. Live animals and skins of animals raised in captivity must be tagged (fee, 5 cents for each tag).

Bounties: None paid.

⁴⁴ *Michigan:* Beaver season closed until 1925. Houses or dams of fur animals protected at all times. Fur animals, except beaver, may be destroyed under permit from director, on one's own premises to protect property, but hides must be properly cared for and turned over to the director at expiration of permit. Unlawful to trap on State game preserves or to trap beaver, badger, or muskrat, in and within 2 miles of any city public park containing over 200 acres, of which 150 acres or more is woodland.

MINNESOTA

Open seasons: *Dates inclusive*
Black bear..... Oct. 15-Jan. 1.
Raccoon..... Oct. 15-Nov. 15.
Mink, fisher..... Nov. 15-Mar. 1.⁴⁶
Muskrat..... Mar. 1-Apr. 30.⁴⁶
Skunk..... Oct. 15-Mar. 1.
Beaver,⁴⁷ otter, marten..... No open season.
Weasel, wolf, wildcat, lynx, fox..... Unprotected.

Prohibited methods: Use of poison prohibited, except as permitted by commissioner. Unlawful to molest or destroy mink or beaver house, den, dam, or abiding place; to hunt these animals with

dogs; or to take muskrats in any manner except by trapping, but muskrat houses must not be destroyed in placing traps therein. Black bear may not be taken by use of steel traps.

Licenses: Resident only, fee, \$1; issued by county auditors; commissioner may issue licenses (fee, \$1; bond, \$500) to trap a limited number of beaver in any locality; licensee must report number of beaver taken within five days after expiration of license. Owners, lessees, or members of their immediate families may hunt without license during open season on own or leased land occupied by them as a permanent residence. Unlawful to enter growing grain for purpose of killing any wild animal without permission of owner. *Buyer:* Resident, local, \$1; traveling, \$10; nonresident, \$25; wholesale, \$1. *Buyers* must make reports.

Possession and sale: Skins of beaver legally taken, when tagged (fee, \$1.50), and skins of other fur animals legally taken may be possessed, bought, or sold at any time.

Shipment and export: Skins of beaver legally taken, when tagged (fee, \$1.50), and other skins legally taken may be transported at any time. Export of red fox cubs taken in State prohibited. Package or receptacle containing wild animals or parts thereof when transported by a common carrier must have attached a proper coupon tag bearing signature, address, and license number of shipper, together with number and kind of animals or parts thereof contained therein.

Propagation: Wild animals raised in captivity under a \$1 permit from the State game and fish commissioner may be sold for breeding or stocking purposes at any time, and under regulations of the commissioner may be killed and any part thereof sold or transported. Under regulations of the commissioner, wild animals may be captured for breeding purposes.

Bounties: Wolf, \$15; cub wolf, \$6; paid by State. County or town boards may offer bounty on wolf, gopher, ground squirrel, groundhog, rattlesnake, crow, or blackbird.

⁴⁶ *Minnesota:* Owner may obtain permit to kill muskrat, mink, or beaver or to destroy their houses or dams when damaging his property.

⁴⁷ A limited number of beaver may be taken under a special license from the commissioner (see "Licenses").

MISSISSIPPI ⁴⁸

Open seasons: *Dates inclusive*
Bear..... Nov. 15-Mar. 1.
Other fur animals..... Unprotected.

Prohibited methods: Unlawful to trap bear.

Licenses: Nonresident, \$20 (county license, bears only); issued by sheriff. Landowners and their nonresident relatives and friends may hunt without license during open season on own lands.

Possession and sale: Sale of bears prohibited.

Shipment and export: Export of bears prohibited. All packages containing dead animals, or parts thereof, shipped within the State shall be open to view, clearly marked with names of the consignor and consignee, and an itemized statement of the number of each species.

Propagation: No legislation.

Bounties: None paid.

⁴⁸ *Mississippi:* The game and fur law enacted in 1922 does not become effective in any county until adopted by the board of supervisors. For information as to whether any boards have adopted the act, address sheriff or county clerk at the county seat of each county. The provisions of the law relating to fur animals are as follows:

Open season: Bear, Nov. 1-Feb. 28; fox, Sept. 1-Mar. 31; raccoon, muskrat, otter, skunk, weasel, Nov. 1-Jan. 31; beaver, protected to Jan. 1, 1930; opossum, wildcat, and other fur animals unprotected.

Licenses: Resident, \$10 (not required of person under 16 years of age); nonresident (county license), \$100, issued by sheriff. Written consent required to trap on lands of another, and traps must be visited once in every 36 hours.

Bag limits: One bear a season.

Possession and sale: No restrictions, except that green hides may be possessed only during the open season and the first 10 days of the close season.

Shipment and export: Export of bear prohibited.

MISSOURI

- Open seasons:** *Dates inclusive*
 All fur animals..... Dec. 1-Jan. 31.⁴⁹
- Prohibited methods:** Use of poison or smoke device in taking any protected animal prohibited.
- Licenses:** Hunting license required to trap: Resident, State, \$2.50; county, \$1 (good in county of residence or adjoining county); issued by county clerk or license collector. Nonresident or alien, \$10. Fur dealer, \$5. Issued by commissioner. Written permission required to trap on inclosed premises of another.
- Possession and sale:** Possession and sale of green pelts prohibited during close season, but dry pelts may be possessed and sold during open season and first 10 days of close season.
- Shipment and export:** Shipper must show hunting license to transportation company. Furs taken out of season may not be possessed for any purpose. Dried pelts may be shipped during first 10 days of close season. Shipments must be marked with the name and address of shipper, his license number, date of shipment, and nature of contents.
- Propagation:** Permits to capture fur animals for propagating purposes may be obtained from the State game and fish commissioner, fee, \$5; breeder's permit fee, \$5.
- Bounties:** Adult wolf, coyote, \$10; wild cat, \$5; young wolf, young coyote, or young wildcat, \$3.

⁴⁹ Missouri: Fur animals may be destroyed at any time and in any way by person residing on own land to protect premises from depredations, but pelts of animals so killed may be marketed in season only.

MONTANA

- Open seasons:** *Dates inclusive*
 Marten, fisher, otter, sable, fox..... Nov. 1-Apr. 1.
 Beaver, muskrat..... No open season.⁵⁰
 Other fur and predatory animals..... Unprotected.
- Prohibited methods:** No restrictions.
- Licenses:** Trapping license, \$10 (issued only to holder of a \$2 resident general hunting license); special permit required to trap beaver, on own land when doing damage, or to export their skins; special license (trapping on State game preserves), \$5; issued by State game warden. Trapping license not required of minors under 15 years of age.
- Possession and sale:** Sale and shipment of beaver skins prohibited, except that skins legally taken under permit and tagged may be shipped or sold within State or they may be exported under permit from the State game warden. No other restrictions on skins legally taken.
- Shipment and export:** (See Possession and sale and footnote 50.) No restrictions on skins legally taken, possessed, or tagged. Permit required to ship out furs; packages must be marked to show contents.
- Propagation:** No legislation.
- Bounties:** The livestock commission may make regulations governing the payment of bounties.

⁵⁰ Montana: Unlawful to kill beaver except when doing damage to own land under a special permit from the State game warden (fee, \$10). All skins of animals so taken must be properly cured and forwarded to the State game warden, Helena, to be tagged with a numbered metal tag (fee, 50 cents for each tag). Tagged skins may be sold or shipped within State, but a shipping permit (fee, 50 cents) must be attached to each shipment sent out of the State.

NEBRASKA

- Open seasons:** *Dates inclusive*
 Muskrat, otter, mink, fox..... Nov. 16-Mar. 1.
 Raccoon, opossum..... Nov. 1-Feb. 15.
 Beaver..... Nov. 1-Jan. 31.⁵¹
 Other fur animals..... Unprotected.
- Prohibited methods:** Unlawful to use spear or like device in hunting or taking fur animals, or explosives, chemicals, mechanical devices, or smokers of any kind, or ferrets to drive fur animals from holes, dens, or houses. Unlawful to disturb or destroy den or house of fur animal, except of muskrat or otter obstructing a public or private ditch or water course; unlawful to cut down or into any tree containing a den.

Licenses: Resident, \$2.10; nonresident or alien, \$25.10; buyer, \$1; issued by State department of agriculture and authorized vendors.

Possession and sale: Possession of green hides prohibited, except during open season and 30 days thereafter. Beaver skins coming from without the State, upon being inspected and stamped by State warden, may be possessed and sold at any time. No other restrictions on skins legally taken.

Shipment and export: Green hides may be transported by express, baggage, or mail during open season and 30 days thereafter, if package is labeled (in two places) with name of consignor, number of his trapping license, and number and kind of hides. No other restrictions on skins legally taken.

Propagation: Fur animals raised in captivity under \$2 breeding license may be sold alive and transported for breeding purposes, and the skins, when tagged and labeled with name of licensee, number of license, and kind and number of skins may be sold and transported at any time.

Bounties: Counties that have voted at any general election to pay bounties may pay for wolf, \$6; coyote, \$3; mountain lion, \$3; wildcat, \$1.

⁵¹ Nebraska: Fur animals, except beaver, may be taken at any time necessary for the protection of property.

⁵² Beaver damaging property may be killed on own land from August 1 to October 31, and under a permit from chief game warden may be killed at any time, but such killings must be reported to State department of agriculture.

NEVADA

- Open seasons:** *Dates inclusive*
 Beaver,⁵³ otter..... Jan. 1, 1930.
 Bear, raccoon, marten, fisher, mink, skunk, fox..... Nov. 15-Mar. 15.
- Prohibited methods:** Unlawful to take fur animals in any manner except by trap or gun, to dig out or drive skunks from dens by use of chemicals, or to molest or destroy any muskrat nest.
- Licenses:** Hunting license required: Resident citizen, \$1.50; nonresident citizen, \$10. License not required of minors under 14, nor of persons trapping on own land.
- Possession and sale:** Unlawful to possess beaver or other skins unless it can be shown that they were legally taken. No other restrictions.
- Shipment and export:** No restrictions on skins legally taken.
- Propagation:** Game or fur animals (except beaver) raised in a licensed preserve (fee, \$10) may be sold or shipped at any time under invoice.
- Bounties:** Mountain lion, \$5; lynx or wildcat, \$2; paid by county. Counties pay bounty of 1½ cents each for pocket gophers when at least 100 heads are presented at one time.

The State board of livestock commissioners is authorized to pay bounty from funds derived from tax on horses, cattle, and hogs. The rewards for coyote, coyote pup, wildcat, or lynx are 75 cents each; for mountain lion, \$5.

The State board of sheep commissioners is authorized to pay bounty from funds derived from tax on sheep, the payments being the same as those made by board of livestock commissioners.

⁵³ Nevada: Beavers doing damage to property may be trapped under authorization from the board of county commissioners. Furs of animals so taken must be preserved and turned over to the board for sale, half of the proceeds to be returned to the trapper. Other fur animals injuring property may be killed in any manner at any time.

NEW HAMPSHIRE

Open seasons: ⁴⁴	Dates inclusive
Sable, otter, fisher, mink, martin, muskrat, ⁴⁵ skunk, fox, ⁴⁶ (see exception).....	Nov. 1-Feb. 28. Exception: In Carroll, Coos, and Grafton Counties.....
Raccoon.....	Oct. 10-Feb. 28. Nov. 1-Dec. 31, ⁴⁸
Beaver.....	No open season.
Other fur animals.....	Unprotected.

Prohibited methods: Bear traps must be safeguarded in a substantial manner. Use of set guns or snares is prohibited. Unlawful to destroy a muskrat house or set a trap therein, thereon, or at the entrance thereof.

Licenses: Resident, \$1; nonresident, \$15; issued by commissioner or agents. License not required of resident landowners and their minor children to trap on own farm lands during open season. No person may trap on lands of which he is not the owner or lessee without permission of owner. All metal traps must be legibly marked or stamped with the trapper's name, and must be visited at least once every 24 hours. Unlawful to take traps of another or to remove fur animals from them. Trappers are liable for any damage to domestic animals by traps.

Possession and sale: Possession of fur animals permitted only during open season, but skins legally taken may be bought or sold at any time. **Shipment and export:** No restrictions on skins legally taken and possessed.

Miscellaneous: Unlawful to tear down or destroy any fence or wall, leave open any gate or bar, or trample or destroy any crop on land of another while trapping or pursuing wild animals.

Propagation: Permit (fee, \$2) required to propagate fur animals, game, or fish.

Bounties: Bear, \$5; hedgehog, 20 cents; wildcat, \$25; paid by State, through the selectmen of towns.

⁴⁴ *New Hampshire:* Fur or predatory animals may be killed at any time when destroying domestic animals or fowls.

⁴⁵ Muskrats may also be taken from the waters of the Connecticut River during the month of March.

⁴⁶ Raccoons and foxes may also be taken by use of dog and gun during the month of October.

NEW JERSEY

Open seasons:	Dates inclusive
skunk, mink, muskrat, ⁴⁷ otter.....	Nov. 15-Mar. 1.
Raccoon.....	Oct. 1-Dec. 15.
Beaver.....	No open season.
Other fur animals.....	Unprotected. ⁴⁸

Prohibited methods: Muskrat, skunk, mink, and otter may be taken by trap only. Unlawful at any time to disturb the lodge or nesting chamber of muskrat.

Licenses: Hunting and fishing license required to trap: Nonresident, \$10.50; resident, \$1.65. Issued by county, city, or town clerk, salaried wardens, or registrars of licenses. Resident minors under 14 may trap without license. Occupant and immediate members of his family residing on farm may trap thereon without license during open season.

Possession and sale: Possession of raccoon permitted during open season and 10 days thereafter. Skins legally taken may be possessed or sold at any time. Possession of live fox prohibited except by permission of board of fish and game commissioners.

Shipment and export: Export of raccoon prohibited, except by nonresident licensee. No other restrictions on skins legally taken or possessed.

Miscellaneous: Unlawful to molest trap set by another or to take animal caught in such trap. Unlawful to liberate fox in State.

Propagation: No restrictions except those imposed by close seasons, during which fur animals may not be taken for breeding purposes.

Bounties: Fox, \$3; woodchuck, amount, not exceeding 50 cents, fixed by boards of chosen freeholders; paid by counties.

⁴⁷ *New Jersey:* Muskrats may be killed at any time by owner of canal or dam which they are destroying.

⁴⁸ Foxes may be hunted with hounds and firearms in daylight from November 10 to April 30, except during open season for deer (December 17 to 21). Killing of fox must be reported to commissioners or county warden within 48 hours.

NEW MEXICO

Open seasons:	
Beaver.....	No open season. ⁴⁹
All other fur animals.....	Unprotected.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: Permit from State game warden required.

Bounties: None paid by State.

⁴⁹ *New Mexico:* When destroying property beaver may be killed under permit from State game and fish warden.

NEW YORK

Open seasons:	Dates inclusive
Bear.....	Oct. 15-Nov. 15.
Mink, sable.....	Nov. 10-Mar. 15.
Skunk.....	Nov. 10-Feb. 10. ⁵⁰
Muskrat (see exception).....	Dec. 1-Mar. 31. ⁵¹

Exception: In Clinton, Essex, Franklin, Hamilton, Jefferson, Lewis, St. Lawrence, Warren, Washington, and that portion of Herkimer County north of the towns of Ohio and Russia.....

Dec. 1-Apr. 30.

Raccoon (in Orleans County, no open season)..... Nov. 10-Feb. 10.

Beaver..... No open season.⁵¹

Prohibited methods: Use of chemicals, gas, or other poisonous substances prohibited. Skunks may not be taken by the aid of dogs or by digging out or driving them from dens or holes by smoking. Unlawful to kill muskrats by shooting, except they may be taken with a 22-caliber rifle in the counties bordering upon Lake Champlain; to take them in box, wire, or cage traps; or to molest, injure, or disturb muskrat houses or dens.

Bag limits: One bear a season.

Licenses: Resident, \$1.25; nonresident, \$10.50; issued by county, city, town, or village clerks. Owners or lessees and members of immediate families actually occupying cultivated farm lands may trap fur animals thereon without license during open season. Minors under 16 may trap fur animals without a license. Indian resident or member of Six Nations residing on reservation wholly or partly within State, fee \$1.25. Only licensed Indians residing on a reservation may take fur animals thereon. Alien not permitted to hunt or kill wild animals except under special license from the conservation commission, or to own or possess shotgun or rifle.

Possession and sale: Fur animals may be possessed during open season only, but hides of fur animals legally taken and possessed may be bought or sold at any time.

Shipment and export: Shipment and export prohibited, except hides of fur animals legally taken and possessed may be transported at any time. **Miscellaneous:** Traps used for taking fur animals protected by law may not be staked or set during close season.

Propagation: Protected fur animals may be kept alive in captivity for propagation and sale, under license from the conservation commission (fee, \$5). No fur-bearing animals may be kept which

NEW YORK—Continued

are taken wild during close season for such animals (unless taken under license); nor may they be disposed of during close season. The conservation commission is authorized to issue license to capture animals for propagation; fee for permit, \$1. License to breed or sell ferrets, fee, \$10; to possess ferret without breeding, fee, \$2.

Bounties: Panther, \$20; paid by State.

⁶⁰ *New York:* If injuring property, skunks may be taken at any time and in any manner, but the skins of animals so taken shall not be possessed, sold, bought, or trafficked in.

⁶¹ In sections of State designated by conservation commission beaver may be trapped March 1–March 31.

NORTH CAROLINA

[More than half of the 100 counties in the State have local laws relating to fur animals. Information regarding open seasons, license requirements, and trapping and hunting restrictions in the various counties may be obtained from the Legislative Reference Librarian, Raleigh.]

NORTH DAKOTA

Open seasons: *Dates inclusive*
Mink Nov. 16–Apr. 14.⁶²
Muskrat Jan. 10–Mar. 10.
Beaver, otter No open season.
Other fur animals Unprotected.

Prohibited methods: Unlawful to cut into, molest, destroy, or dynamite any beaver dam or beaver or muskrat house or mound, or to shoot muskrats.

Licenses: Resident, \$2; nonresident, \$25; issued by commissioners, deputies, and county auditors. License not required of person under 16 years of age, or of resident or member of family residing permanently with him, to trap on own cultivated land, during open season. Unlawful to trap muskrats on posted lands of another. Alien prohibited from hunting, taking, or killing any wild animal, except in defense of person or property.

Possession and sale: Skins of fur animals legally killed within or without the State may be possessed or sold at any time. Green hides of mink or muskrat may be possessed only during open season and first five days of close season.

Shipment and export: Shipment and export prohibited, except that skins of fur animals legally taken within or without the State may be shipped at any time.

Propagation: The State game and fish board issues permits (fee, \$5) to breed and domesticate fox, mink, muskrat, skunk, and raccoon, and also permits to sell or ship them when raised in captivity. Under permit from board and \$500 bond, such fur animals may be taken at any time for breeding purposes. Annual reports are required of licensed breeders.

Bounties: Adult wolf or coyote, \$5; pups, \$2 each.

⁶² *North Dakota:* Minks may be killed at any time to protect one's own property.

OHIO

Open seasons:⁶³ *Dates inclusive*
Raccoon, fox, skunk, opossum Nov. 15–Feb. 1.
Muskrat, mink Nov. 15–Mar. 1.
Other fur animals Unprotected.

Prohibited methods: Unlawful to dig out or destroy the house, den, or burrow of fur animals or to smoke or drown the animals therefrom.

Licenses: Resident, \$1.25; nonresident, \$15; issued by county and township clerks. Alien prohibited from hunting or trapping. License not required of owners, managers, tenants, or their children to trap during open season on own land. Written permission from owners or authorized agents required to trap on lands of another.

Possession and sale: Possession of fur animals during close season prohibited, but skins legally taken may be possessed or sold at any time. Raccoons legally taken may be possessed alive in inclosures as pets.

Shipment and export: Shipment and export prohibited, except that skins legally taken may be transported at any time. Packages containing fur animals or parts thereof when transported by common carrier must be marked to show contents, initial point of billing, and names and addresses of consignor and consignee.

Propagation: No restrictions, except those which prevent capture of wild stock in close season.

Bounties: Townships pay a bounty of \$1 each on certain hawks and the great horned owl.

⁶³ *Ohio:* Protected fur animals, when damaging property, may be destroyed by owners or tenants of land (except on Sunday).

OKLAHOMA

Open seasons: *Dates inclusive*
Beaver, otter No open season.
Bear (see exception) Unprotected.
Exception: In Blaine, Caddo, Comanche, Kiowa, and Major counties No open season.
Other fur animals Nov. 1–Mar. 1.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: Unlawful to sell pelts of fur animals taken during close season. No other restrictions.

Shipment and export: No restrictions on skins legally taken.

Propagation: The State game warden issues permits to propagate fur-bearing animals (fee, \$2, together with fees for tagging). Licensed breeders may sell and transport animals raised in preserves under rules prescribed by the warden.

Bounties: County commissioners are authorized to offer bounty on gray wolf or coyote (\$5), and may also pay bounty of not exceeding 5 cents each on crows, English sparrows, hawks, rabbits, prairie dogs, pocket gophers, and ground squirrels; State pays bounty of 25 cents each on hawks and crows; paid by county clerks under regulations of State game and fish warden.

OREGON

Open seasons:⁶⁴ *Dates inclusive*
Beaver (see exception), mink, otter, fisher, marten, muskrat, raccoon Nov. 1–Feb. 28.⁶⁵
Exception: Beaver on national forests and in Coos, Curry, Douglas, Jackson, and Josephine counties, no open season.

Other fur animals Unprotected.

Prohibited methods: Unlawful to destroy muskrat house, except where it obstructs ditch or watercourse.

Licenses: Fee, \$2; issued by State game commission. License not required for trapping on own land. Special beaver trapping license, fee, \$2. Fur dealer, \$3. Licensee must keep chronological record showing number and kind of furs purchased, and names and addresses of persons from whom obtained, and make verified annual report to commission. Unlawful to remove or disturb traps of a licensed trapper on public domain or on land where he has permission to trap. Licensed trappers are required to make annual reports of number of animals caught, receipts for fur, and where sold.

Possession and sale: Possession and sale prohibited, except that animals or hides legally taken within or without the State may be possessed or sold at any time.

Shipment and export: Shipment and export prohibited, except that skins of animals legally taken may be shipped at any time.

Miscellaneous: Unlawful to use the flesh of a game bird or animal for trap bait.

Propagation: Permits (fee, \$2) to keep fur-bearing animals may be obtained from the State game commission. No wild fur animals may be taken for propagating purposes in close season nor may those held in captivity under permits be sold in that season. Yearly reports to the commission are required.

OREGON—Continued

Bounties: Coyote or coyote pup, \$3; adult female coyote, \$4; gray, black, or timber wolf, or wolf pup, \$2.50; bobcat, wildcat, or lynx, \$2; mountain lion, panther, or cougar, \$10; seal or seal pup (including only hair, spotted, or leopard seals), \$2.50; paid by county and half refunded by the State. The State game commission is empowered to pay additional bounties on any predatory animal in order to protect game; under this act it now pays for wolf, \$20; for cougar, \$15. Several counties are authorized to pay bounties on moles, rabbits, and gophers.

⁶⁴ *Oregon:* Unlawful to hunt or trap fur animals on State game preserve.

⁶⁵ Beavers doing damage may be killed on own or leased property, and the hides of beavers so killed are the property of the person killing them; other fur animals damaging property may be killed under permit of State game warden, but skins of animals so taken must be delivered to the state game commission for disposition.

PENNSYLVANIA

Open seasons: ⁶⁶	Dates inclusive
Bear ⁶⁷	Nov. 1-Dec. 15.
Raccoon	Oct. 1-Feb. 15.
Muskrat, skunk, mink, otter, opossum	Nov. 1-Feb. 28.
Fox, wildcat, weasel	Unprotected.
Beaver	No open season.

Prohibited methods: Unlawful to take bears with steel trap, deadfall, or pen, or to shoot them except with a single bullet, but the use of steel-jacketed bullets is prohibited. Steel traps having a spread of jaws greater than 6½ inches may not be used for trapping fur animals or vermin. All traps must bear metal tag showing name and address of owner, must be visited once in every 36 hours, and at end of open season must be taken up or sprung. Unlawful to dig out fur animals; to drive them from holes or dens by use of smoke, explosives, or chemicals; to cut den trees; or to take fur animals by use of poison. Beaver houses and dams are protected, except under special permit. Unlawful to disturb traps of another or to remove fur animals therefrom.

Bag limits: One bear a season, or 4 to a camp or body of men.

Licenses: Nonresident, \$15; issued by commission or county treasurer. Resident, \$1.25 (fee of 15 cents extra to justice of peace); issued by county treasurer. Minors under 16 years of age may trap fur animals and vermin without a license. Licensee required to wear tag on middle of back. Resident citizen, members of family, and regularly hired help, residing on and cultivating land may hunt on such land, and, with consent of owner, on adjoining land without a license, during open season. Alien not permitted to hunt or kill any wild animal in State, except in defense of person or property. Trapper must report to board of game commissioners number of each kind of fur animals killed. Fur dealer, \$1.

Possession and sale: Bear may be possessed only during open season and first 30 days of close season. Bear and raccoon skins taken during open season may be possessed or sold at any time. Raw skins may be possessed during the open season and the first 15 days of close season.

Shipment and export: Raccoons legally taken may be shipped or exported at any time. Packages must be plainly marked to show contents, name and address of owner, and county in which taken. Shipment by parcel post prohibited. Nonresident licensee may take out 1 bear legally killed. No other restrictions on skins legally taken and possessed.

Propagation: No restrictions on raising fur animals, except that possession and breeding of ferrets is unlawful except under license from State board of game commissioners: fee for license to breed and sell ferrets, \$25; to possess a ferret without breeding, \$1.

Bounties: Wildcat, \$15; gray fox, \$4; red fox, \$2; weasel, \$1. Affidavit on form supplied by game

commission must accompany entire unutilized skin of animal when presenting claim to board of game commissioners, at Harrisburg, Pa.

⁶⁸ *Pennsylvania:* Fur animals may be killed or captured alive by landowners or tenants and their employees at any time to protect their growing crops.

⁶⁹ Bears may be killed at any time in defense of person or property. The board of game commissioners, upon petition of 200 citizens of a county showing that bears have become a nuisance, may permit them to be taken at any time, but steel traps and deadfalls may not be used. Animals so taken must be delivered to charitable institutions.

PORTO RICO

Porto Rico has no wild fur animals.

RHODE ISLAND

Open seasons: ⁶⁸	Dates inclusive
Skunk	Nov. 1-Apr. 15.
Raccoon	Oct. 1-Feb. 1.
Muskrat, mink, otter	Nov. 1-Feb. 1.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to set wire snares, or to use steel traps with teeth or with spread over 6 inches, or choke traps with greater openings than 6 inches. Traps must be concealed so as not to endanger domestic animals and must be visited at least once every 24 hours.

Licenses: Hunting license required for trapping: Resident, \$1.25; nonresident, \$10.25; alien, \$15.25; issued by town and city clerks. License not required of resident or his immediate family to hunt or trap on agricultural lands on which actually domiciled; nonresident owning real estate valued at not less than \$500, and nonresident member of club incorporated for hunting or fishing purposes prior to Jan. 1, 1909, which owns real estate assessed for taxation at value of not less than \$1,000, may procure license at a fee of \$1.25; nonresident guest of incorporated fox hunting club, \$1.25 (authorizes fox hunting and is good for a period of 6 days); licenses not issued to minors under 15 years of age. Written permission required to trap on inclosed lands of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation.

Bounties: Fox, \$5; crow and certain hawks and owls, 25 cents; paid by State.

⁶⁹ *Rhode Island:* Landowner may kill fur animals on own land at any time.

SOUTH CAROLINA

Open seasons:	Dates inclusive
Bear, mink, muskrat, otter, skunk, raccoon, ⁶⁹ opossum, fox ⁷⁰ and other fur animals	Nov. 27-Mar. 1. ⁷¹

Prohibited methods: Hunting at night prohibited except for raccoon, opossum, or fox. Unlawful to shoot or trap foxes, to dig them out of the ground, or to push or drag them out of a tree or log. Use of deadfall traps prohibited.

Licenses: Hunting license required: Resident, county license, \$1.10; State, \$3.10; issued by county clerk or game warden; nonresident, \$15.25; issued by county clerk. No license required of resident owners, tenants, their children, or, under written permission, their employees to hunt during open season on own lands. Consent of owner or manager required to hunt or trap on lands of another.

Possession and sale: No restrictions on skins of fur animals legally taken.

Shipment and export: Skins of fur animals must be tagged by State warden or deputy before being shipped or transported. Tag fees: Otter, red fox, \$1; raccoon, gray fox, mink, 25 cents; skunk, 10 cents; opossum, muskrat, 5 cents. Packages containing furs for transportation must bear certificate of State warden or deputy that the tag

SOUTH CAROLINA—Continued

required to be attached to each pelt has been properly attached and paid for. Person, firm, or corporation shipping furs must make monthly report to county game warden of number of skins shipped or transported. Shipments must be labeled to show the number and kind of skins in the package and the consignor and consignee. No other restrictions on skins of fur animals legally taken.

Propagation: No legislation.

Bounties: None paid.

⁶⁰ *South Carolina:* Raccoons may be killed after July 15 by the owners of crops which they are destroying.

⁷⁰ Foxes doing damage may be shot on one's own premises at any time.

⁷¹ Hunting season for raccoon, opossum, and fox, Sept. 1-Mar. 1. Wildcats may be killed without license at any time by officers of the law and by landowners upon their own holdings.

SOUTH DAKOTA

Open seasons: *Dates inclusive*

Mink, muskrat, skunk (season opens at noon and closes at noon)..... Dec. 1-Mar. 1.⁷²

Beaver,⁷³ otter..... No open season.

Other fur animals..... Unprotected.

Prohibited methods: Unlawful to shoot muskrats, or to destroy or molest muskrat houses, except that these may be opened without injury thereto for the purpose of placing traps therein during open season. No person may set or operate more than 75 traps at any one time.

Licenses: Resident, \$5; nonresident, \$25; issued by game warden and county treasurer. License not required of residents under 14 years of age, nor of landowners trapping on own lands during open season. Unlawful to hunt on cultivated or posted lands of another without permission of owner.

Possession and sale: Unlawful to possess, buy, or sell raw skins of protected fur animals during close season, whether taken or killed within or without the State.

Shipment and export: Unlawful to ship raw skins of protected fur animals during close season, whether taken or killed within or without the State.

Propagation: Not permitted.

Bounties: None paid by State. A county may pay \$50 for each grown wolf, \$4 for each wolf (other than coyote or prairie wolf) less than 1 year old, \$10 for each mountain lion, and \$4 each for coyote or prairie wolf, fox, lynx, and bobcat.

⁷² *South Dakota:* Skunks doing damage around buildings may be killed at any time, and, under permit from State game warden, muskrats or beavers damaging irrigation ditches, embankments, or public highways may be taken at any time.

TENNESSEE

Open seasons: *Dates inclusive*

All fur animals (season opens at noon and closes at noon) (see exceptions)..... Oct. 15-Jan. 15.⁷⁴

Exceptions:

Davidson, Robertson, and Shelby Counties: Beaver, muskrat, fox, mink, raccoon, skunk, opossum..... Sept. 1-Jan. 31.⁷³

Franklin County: Beaver, muskrat, fox, mink, raccoon, skunk, opossum..... Nov. 1-Jan. 31.⁷³

Prohibited methods: Steel traps must be placed at least 12 inches within the entrance to a hole, cave, den, or hollow log.

Licenses: None required. Written consent to trap on lands of another. Traps and deadfalls must be inspected within each 36 hours, and captured animals removed; does not apply to trapping wildcats in Lauderdale County.

Possession and sale: No restrictions, except locally. In Davidson, Franklin, Robertson, and

Shelby Counties the sale of protected fur animals is prohibited during close season.

Shipment and export: No restrictions except locally. In Davidson, Franklin, Robertson, and Shelby Counties it is unlawful to remove any protected fur animal from county during close season.

Propagation: No legislation.

Bounties: Wolf or panther, \$2 certificate issued by county court, the amount to be applied on payment of taxes.

⁷³ *Tennessee:* Fur animals may be taken on one's own land at any time.

TEXAS

Open seasons:

All fur animals (see exception). Unprotected.

Exceptions: In Caldwell

County, mink, raccoon, fox..... No open season.

Prohibited methods: No restrictions.

Licenses: None required. Consent of owner necessary to trap on posted land.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: Permit must be obtained from game, fish, and oyster commissioner to trap or transport wild animals for propagation.

Bounties: None paid.

UTAH

Open seasons:⁷⁴ *Dates inclusive*

Beaver,⁷⁵ otter, marten..... No open season.

Raccoon, skunk, civet cat..... Dec. 15-Mar. 31.

Mink, muskrat⁷⁶..... Dec. 15, 1925.

Other fur and predatory animals..... Unprotected.

Prohibited methods: Use of silencer on gun and discharge of firearm from automobile or within 50 feet of a public highway prohibited.

Licenses: Resident citizen, \$5. Issued by State fish and game commissioner or deputy, county clerk, or deputy or authorized agent. Not issued to minor under 16. Unlawful to disturb or remove traps of licensed trappers on public domain or on lands where they have permission to trap. Aliens other than homesteaders are not permitted to hunt or trap.

Possession and sale: Skins of fur animals legally taken may be possessed and sold at any time, except that the skins of beavers, which may be taken only when doing actual damage to property under permit of the commissioner, must be turned over to the commissioner to be sold by him. Possession of beaver skins prohibited, except by a permit holder, unless tagged by commissioner. Green pelt or carcass of fur animal may not be possessed except during open season and 15 days thereafter.

Shipment and export: Shipment and export of furs legally taken and possessed permitted at any time. (See "Possession and sale" and footnote 75.) Skins of beavers taken under permit of the commissioner may only be shipped by the permittee to the commissioner for sale. Shipment or export of beaver skins prohibited, unless such skins are tagged by the commissioner.

Miscellaneous: Use of the flesh of game animals or birds as trap bait for fur animals prohibited.

Propagation: Permit (no fee) from commissioner required to propagate fur animals, but such animals held under permit may not be killed during close season.

Bounties: Wolf, \$62.50; bear, mountain lion, cougar, \$30; coyote, \$4; lynx, bobcat, \$3.

⁷⁴ *Utah:* Commissioner may shorten or close season on fur animals, or further restrict the number which may be taken, where necessary to afford sufficient protection to any species.

⁷⁵ When beavers are destroying property, the State fish and game commissioner may grant permit to trap them, but the hides of animals so taken must be delivered to and sold by commissioner, who shall recompense for trapping in not more than half of the proceeds from sales.

⁷⁶ Property owner may trap muskrats doing actual damage to dams, ditches, or water courses in sufficient numbers to insure protection to such property.

VERMONT

Open seasons:⁷⁷ *Dates inclusive*
Muskrat (see exception)..... Oct. 25-Apr. 15.

Exception: On shores of Lake Champlain in Rutland County, Poultney River below Carver Falls, and shores of Memphremagog in Orleans County..... Jan. 1-Apr. 30.

Mink, otter, marten, raccoon, fisher, fox,⁷⁸ skunk (see exception)..... Oct. 25-Feb. 15

Exceptions: Fox in Grand Isle County..... Unprotected.

Mink and otter on shores of Lake Champlain in Rutland County, Poultney River below Carver Falls, and shores of Lake Memphremagog in Orleans County..... Jan. 1-Apr. 30.

Beaver..... No open season.

Prohibited methods: The use of set guns, snares, and poisons is prohibited; bear traps must be carefully safeguarded and visited once in 48 hours. Unlawful to open or destroy a muskrat house or to place a trap at its entrance. Unlawful to dig skunks from dens or to drive them out by use of smoke or chemicals, or to dig out fox dens during close season.

Licenses: Resident, 75 cents; nonresident, \$10.50; issued by town clerk. Owners of farm lands and their resident minor children or tenants may take fur animals on own lands during open season without a license. License not issued to person under 16 years of age without written consent of parent or guardian. Nonresident owning improved real estate appraised at not less than \$1,000, upon which he pays taxes, may obtain a resident license. Persons trapping on inclosed lands of another must, within 12 hours, inform owner of location and number of traps and must visit traps at least once in 24 hours.

Possession and sale: Possession of fur animals during close season prohibited, but the fur or skins of animals legally taken may be possessed, bought, or sold at any time.

Shipment and export: Packages containing fur animals or parts thereof delivered to a common carrier for transportation must be tagged to show the number and kind of such animals or skins therein, names of consignor and consignee, station from which shipped, and destination. A person required to have a license must also show the number of his license on the shipping tag. No other restrictions on skins legally taken and possessed.

Propagation: The State fish and game commissioner issues special permits for propagating fur and game animals (fee, \$2 and expense of tagging). Animals bred on fur farms may be sold and transported alive at all times when bearing the identification tags prescribed by the commissioner.

Bounties: Towns pay \$3 bounty on bay lynx or bobcat, and \$1 on rattlesnake.

⁷⁷ Vermont: Fur animals may be killed at any time to protect one's own property.

⁷⁸ Foxes may be taken otherwise than by trapping at any time.

VIRGINIA

Open seasons: *Dates inclusive*
All fur animals (see local laws)..... Dec. 1-Mar. 31.⁷⁹

Albemarle, Amherst, Madison, Nelson, Orange, and Spotsylvania Counties:

Fox (trap)..... Nov. 1-Nov. 20.⁸⁰

Charles City, Essex, James City, New Kent, Warwick, and York Counties:

Muskrat..... Dec. 15-Mar. 31.

Jefferson magisterial district—in Culpeper County:

Fox (trap)..... Nov. 1-Dec. 31.

Open seasons—Continued.

All fur animals—Continued.

Fauquier and Loudoun Counties: Fox..... *Dates inclusive*
Sept. 1-Mar. 31.⁸¹

Henry, Pittsylvania, and Tazewell Counties: Fox..... Sept. 15-Mar. 15.

Patrick County: Raccoon, opossum..... Oct. 15-Mar. 14.

Gray fox..... Sept. 15-Mar. 14.

Princess Anne County: Mink, muskrat, otter (for profit)..... Nov. 1-Mar. 14.

Prohibited methods: Unlawful to take muskrats in tidewater sections of State from one-half hour after sunset to one-half hour before sunrise, except by traps.

Licenses: Hunting license required to trap: Nonresident, \$10; alien, \$20 (alien owner of real estate resident for five years, same as resident). Resident: State, \$3; county of residence, \$1. Issued by clerks of circuit and corporation courts. License not required of residents to hunt foxes with hounds. Residents and nonresidents and their children may hunt on own land during open season without a license. Tenant, under written consent of owner or landlord, may hunt without license during open season on lands on which he resides. Written permission is required to trap or hunt on lands of another.

Possession and sale: No restrictions on skins legally taken, except that sale of red or gray fox is prohibited during close season in Henry County.

Shipment and export: No restrictions on skins legally taken.

Propagation: License required (fee, \$25) to raise game or fur animals.

Bounties: Weasel, \$1; sharp-shinned and Cooper hawk, goshawk, great-horned owl, 50 cents each; crow (if killed April 1-September 30), 15 cents each; paid by county clerk.

⁷⁹ Virginia: Season applies to trapping on lands of another, which is lawful only with written permission of owner, which permission the trapper must have on his person when trapping. Landowner may trap or kill fur animals on his own land at any time.

⁸⁰ Unlawful to shoot a fox in Albemarle, Madison, Nelson, Orange, or Spotsylvania County.

⁸¹ Foxes may be taken at any time by owner or tenant of land to protect property in Fauquier and Loudoun Counties. Written permission of owner required to take foxes on lands of another.

WASHINGTON

Open seasons:

Beaver..... No open season.

Bear and other fur animals (open season fixed by county game commissions).^{82 83}

Prohibited methods: No steel trap larger than No. 4 may be used unless a notice in the English language on a large placard is placed above the trap.

Licenses: County, \$5; issued by county auditor. License not required of landowners and leaseholders trapping on own premises, nor of minors under 16 years of age.

Possession and sale: Carcass and pelt of bear lawfully taken may be sold at any time; beaver skins secured without the State, if inspected and tagged (tag, 10 cents) by supervisor of game and game fish, may be possessed or sold at any time. Other furs legally taken coming from without State may be possessed, sold, and transported, if reported to supervisor of game and game fish or county game commission, within 3 days after arrival, and tagged (tag, 10 cents).

Shipment and export: Carcasses and pelt of bear and skins of other fur animals legally taken and possessed may be shipped at any time.

Propagation: Breeder's license (fee, \$10; renewal, \$5) required.

Bounties: None paid by State. Counties are permitted to pay bounties on mountain lion or

WASHINGTON—Continued

cougar, lynx or wildcat, coyote, timber wolf, bear, muskrat, squirrel, and in the Columbia River district on seal or sea lion.

⁸² *Washington*: Communicate with county game commission at county seat, or supervisor of game and game fish, Box 384, Seattle. Bears may be killed at any time when destroying domestic animals.

⁸³ Under written permission from county game commission or supervisor of game and game fish, landowners and leaseholders may trap muskrats and moles doing damage to property.

WEST VIRGINIA

Open seasons: ⁸⁴	Dates inclusive
Skunk.....	Dec. 1-Feb. 1.
Red fox, in Brooke, Cabell, Doddridge, Harrison, Kanawha, Mason, Mingo, Morgan, Pleasants, Roane, Summers, Taylor, Upshur, Wetzel, Wirt, and Wyoming Counties only.....	Dec. 1-Feb. 1.
In rest of State.....	Unprotected.
Raccoon, mink, and other fur animals.....	Unprotected.
Prohibited methods: Unlawful to set a steel or spring bear trap on land of another.	
Licenses: Hunting license required to trap skunks: Resident, \$1; nonresident, \$15; issued by county clerk. Resident landowner, his resident children, or tenants, may hunt during open season on own land without a license. License not required of minor under 15 years of age. Express permission of owner or tenant required to set or maintain a snare or trap upon land of another. Licensee must wear tag.	
Possession and sale: No restriction on skins legally taken.	
Shipment and export: No restrictions on skins legally taken.	
Propagation: No restriction on possession or sale, but animals must not be taken for breeding purposes in close season except on lands owned or tenanted by the breeder.	
Bounties: Wildcat, bobcat, or catamount, \$5; crow, 10 cents; certain hawks and owls, 25 cents; paid from forest, game, and fish protection fund.	

⁸⁴ *West Virginia*: A landowner, his agent, or tenant may hunt or kill fur animals on his own lands at any time.

WISCONSIN

Open seasons:	Dates inclusive
Beaver, ⁸⁵ otter, marten, fisher, raccoon.....	No open season.
Mink.....	Nov. 1-Mar. 31.
Skunk.....	Oct. 15-Jan. 31.
Muskrat.....	Oct. 25-Mar. 31. ⁸⁶
Black bear.....	Unprotected.
Prohibited methods: Unlawful to take fur animals with the aid of spear, gun, or dog; to disturb or molest muskrat houses, beaver houses, or beaver dams, or to molest or disturb raccoon den trees.	
Licenses: Resident, \$1, issued by conservation commission. Each trap must be tagged, fee, 5 cents each. Report required from licensed trapper on or before June 1 of each year. Nonresident not permitted to trap; alien not permitted to hunt. Written consent of owner or occupant required to trap minks or muskrats on agricultural lands of another.	
Possession and sale: Possession of green skins of fur animals permitted only during open season and first five days of close season; possession prohibited of the skin of a mink or muskrat which shows that the animal has been shot or speared. No other restrictions on possession and sale of skins legally taken.	
Shipment and export: Shipment of hides must be marked to show the number and kinds of hides, the name and address of the shipper, and the number of his trapping license.	
Propagation: Under license and supervision of the commission beaver, muskrat, or skunk may be	

taken and transported for propagation within the State. Special license required for beaver farming (fee, \$2.50, and 25 cents per acre for all land in excess of 10 acres). Special license required for muskrat or skunk farming (fee, \$2.50, and 15 cents per acre for all premises in excess of 10 acres covered by the license).

Bounties: Wolf cub taken between March 1 and November 1, \$4; mature wolf killed at any time, \$30; fox, \$2; paid by State. County boards may offer bounty on crow, hen hawk, pocket gopher, streaked gopher, ground hog or woodchuck, English sparrow, blackbird, or rattlesnake.

⁸⁵ *Wisconsin*: If beavers damage property, they may be captured and removed under permit and the direction of the State conservation commission; skins of animals that are killed in taking must be delivered to the conservation commission. Owners or lessees of dams, under permit of conservation commission, may destroy at any time muskrats to protect such dams or levees, but they may not sell, barter, or give away the skins of such animals killed during close season.

WYOMING

Open seasons:	
Beaver.....	No open season. ⁸⁷
All other fur animals.....	Unprotected.
Prohibited methods: Unlawful to trap bears.	
Licenses: For trapping in State game preserves, fee, \$5; for trapping in national forests, \$5; issued by State game and fish commissioner. Employees of the Federal Government do not require permit to trap predatory animals. For bear: Resident (hunting license), \$2.50; nonresident, \$25; limit, 3 bears; issued by commissioner. Nonresident may take 3 bears Sept. 15-Nov. 15 under big game license. The killing of a bear must be reported not later than December to the commissioner. Dog license, \$1 (required for each dog used in hunting predatory animals in national forests). Permission of owner required to hunt or trap on inclosed lands of another.	
Possession and sale: Skins of beavers killed when doing damage to real estate may be possessed when duly tagged by commissioner and affidavit is furnished the commissioner by the owner of the real estate showing the damage and number of beavers killed, and upon the payment of 50 cents for each beaver hide.	
Shipment and export: Beaver hides must be tagged by commissioner before being shipped or transported.	
Miscellaneous: Use of the flesh of game animals or birds as trap bait for predatory animals prohibited.	
Propagation: Beavers may be taken for propagation under a \$5 permit, but animals so taken must be kept 3 years before being killed or sold.	
Bounties: None paid by State.	

⁸⁶ *Wyoming*: Close season on beaver expires Mar. 15, 1925. If beavers damage real estate the owner thereof may destroy them, but must furnish State game and fish commissioner with affidavit showing damage and number killed.

Laws of Canada

ALBERTA

Open seasons: ⁸⁷	Dates inclusive
Mink, fisher, marten, fox.....	Nov. 1-Mar. 31. ⁸⁸
Otter.....	Nov. 1-Apr. 30.
Muskrat (see exception).....	Dec. 1-Apr. 30.
Exception: South of North Saskatchewan River.....	No open season. ⁸⁹
Beaver.....	Dec. 31, 1925. ⁹⁰
Other fur animals.....	Unprotected.
Prohibited methods: Unlawful to use poison for taking fur animals; or to destroy, partially destroy, or to leave open any muskrat or beaver house or beaver dam.	
Licenses: <i>Trapping:</i> Resident, \$2; nonresident, \$25; issued by minister of agriculture. License not required of farmer, or member of his family while actually residing with him upon his farm, for trapping on own land. Consent of owner or occupant required to trap on inclosed or culti-	

ALBERTA—Continued

vated lands of another. Permits to trap on game or forest reserves may be granted under regulations of the lieutenant governor in council. **Taxidermist:** \$5. Dealer in furs and skins of protected animals at a specified place of business, or within 1 mile thereof: Resident of a city, \$25; resident outside of a city, \$10; nonresident, \$100. Traveling license issued to holder of a dealer's license or his manager upon payment of fee of \$15. Traveling buyer: Resident, \$25; nonresident, \$100. Nonresident buying wholesale from licensed dealers, \$5 (good for 10 days only). Licensee must make semiannual reports to department of agriculture. License to sell skins by tender or auction, fee, \$25. Issued by minister or agents.

Possession and sale: No restrictions on prime skins legally taken and possessed.

Shipment and export: Export of furs and skins prohibited except under permit from minister. No furs or skins on which royalty has not been paid may be exported, and a special permit from the minister is necessary to ship out unprime skins. Export of live wild foxes prohibited.

Propagation: Manager of fur farm required to make reports January 1 and July 1 of each year. Export of live animals from fur farms allowed only on permit from the minister of agriculture. Permit, with fees, required to export live muskrat, mink, fisher, marten, otter, or beaver, whether raised on a fur farm or otherwise (orders in council).

Bounties: The council of any rural municipality is authorized to offer a bounty on wolf.

⁹¹ Alberta: lieutenant governor in council may change close seasons on fur animals.

⁹² Unlawful to trap fox for export.

⁹³ Unlawful to destroy a beaver dam unless authorized to do so by the lieutenant governor in council, who may also authorize the killing of beavers or other fur animals when such killing is deemed to be in the public interest.

⁹⁴ Lieutenant governor in council may declare open seasons locally on beaver and muskrat.

BRITISH COLUMBIA

Open seasons: ⁹¹

Prohibited methods: Unlawful to use poison in taking fur animals, except that farmers and poultrymen may protect own stock; to destroy muskrat or beaver houses, except under permit to prevent damage on dyked or agricultural lands; or to hunt fur animals at night.

Licenses: **Trapping:** Resident, British subject, \$10; nonresident or resident alien not permitted to trap; nonresident special license to hunt—not trap—bears from January 1 to July 1, \$25; nonresident general hunting license, fee, \$25, and additional fees of \$15 to \$25 for each bear killed. License not issued to boys under 18 years of age without written consent of parent or guardian. Issued by provincial game warden or authorized agent. Licensee must wear badge. Permission of owner required to trap on inclosed, cleared, or cultivated land of another. A licensed trapper who first occupies a trap line not later than 15 days after the beginning of any open season for trapping is protected against other trappers. Unlawful to touch or interfere with traps set by a licensed trapper. License must be returned within two months after it expires, with a statement of number of fur animals of each kind taken. **Fur dealer:** Resident, \$25 (does not apply to licensed trapper selling skins taken by himself); nonresident or his agent, \$200. License required for each place of business. Fur dealer must make verified report every three months, showing number and kind of skins purchased and date of transactions. **Taxidermist:** \$5. **Trapper:** \$5. Game conservation board may grant permits (fee, \$25) to buy furs at wholesale from licensed fur dealers or at public auction.

Possession and sale: Unlawful to sell pelts taken during close season or to possess unprime furs. Possession of pelts of fur animals allowed only

during open season and for two months thereafter (three months, north of 52d parallel), except under special permit from game conservation board. Unlawful for fur trader to possess skins on which royalty has not been paid. Does not apply to skins taken by a licensed trapper if sold to a licensed resident dealer nor to skins of animals raised in captivity. Bears may be sold only as permitted by regulations.

Shipment and export: Export of pelts of fur animals allowed only during open season and for two months thereafter (three months, north of 52d parallel), under special permit of game conservation board. Packages must be prepared so that they may be easily opened for examination, or labeled with a full description of the contents, and names and addresses of the consignor and consignee, and accompanied by export permit.

Propagation: A permit from the game conservation board is required to propagate fur-bearing animals or to take them for breeding purposes. Breeder must keep a record of transactions as to purchases and sale of stock, which record must be open to inspection of any game warden, and must make verified report to game conservation board on or before August 31. Live animals and birds may be exported only under permit; and a permit is required to take foxes or other fur animals in close season.

Bounties: Panther, \$40; timber wolf, \$25; coyote, \$2 (if not less than one week old); big-horned or snowy owl, \$1; magpie and crow, 20 cents each; eagle, \$1. (Rates fixed from time to time by lieutenant governor in council.)

⁹¹ British Columbia: Seasons on fur animals fixed annually by lieutenant governor in council. For regulations apply to secretary game conservation board, Vancouver, British Columbia.

MANITOBA

Open seasons: ⁹¹

North of fifty-third parallel—	Dates inclusive
Fisher, pekan, sable, marten, mink.....	Nov. 1-Mar. 31.
Otter, beaver.....	Nov. 1-Apr. 30.
Muskrat.....	Mar. 15-May 15.
Fox, lynx.....	Nov. 1-Feb. 28.
South of fifty-third parallel—	
Fisher, pekan, sable, marten, mink.....	Nov. 1-Mar. 31.
Otter, beaver ⁹²	No open season.
Muskrat.....	Mar. 15-Apr. 30.
Fox, lynx.....	Unprotected.

Prohibited methods: Use of poison or dog in taking or hunting fur animals is prohibited. Unlawful to shoot or spear muskrats or to destroy muskrat houses. Beaver houses and dams protected, except under permit to protect property.

Licenses: **Trapping:** Resident, \$2; nonresident Canadian citizen, \$50; nonresident alien, \$200; issued by minister of agriculture and immigration. Permission of owner required to trap on cultivated or inclosed lands of another. Licensee must return his license and make a report during the month of June, showing the number of each kind of animals taken. **Fur trading:** Nonresident trader, \$50; traveling fur buyer, \$25; resident raw fur merchant or dealer, \$10; resident traveling agent, \$10; issued by minister. Licensees are required to keep record and to make monthly reports of furs handled. **Fur dressing and tanning:** \$10; issued by minister. Licensee must keep records and report to the chief game guardian on or before the 10th of each month the number of royalty pelts handled and the name and address of person forwarding or delivering the skins.

Possession and sale: Possession of unprime skins prohibited. Unlawful to purchase or sell the skins of muskrats that have been speared or shot. Any person purchasing or acquiring pelts from a trapper must ascertain that he holds proper trapping permit and at the same time record his name and the number of his permit. Unlawful to purchase, barter, or trade the pelt of a fur animal taken during the close season (does not apply to imported skins). No other restrictions on skins legally taken.

MANITOBA—Continued

Shipment and export: Export prohibited of unprime skins or skins on which royalty is payable unless such skins have coupons attached to show royalty paid; each shipment must be accompanied by a permit procured from minister upon surrender of counterpart of royalty coupon, and have attached a declaration of the number and kinds of skins contained, and also set forth that counterfoils of royalty coupons are attached as required. Shipment or removal from Province prohibited except by express or mail. No other restrictions on skins legally taken. Export prohibited of live protected animals (except ranch-bred animals) except under permit from minister of agriculture and immigration (permit must accompany shipment to destination); fees, for black or silver fox, \$100; for other fox, \$15; for otter, \$25; for beaver, \$5; for mink, fisher, or marten, \$1; for muskrats, \$2 a dozen or fraction thereof.

Propagation: License (fee, \$5) must be obtained from the minister to operate a fur farm. Licensee, on or before the first days of January and July, must make verified reports showing the number, species, age, and sex of the animals on hand, from whom procured, and the number which have died during previous six months, with cause of death.

Bounties: Timber wolf,⁹⁴ \$5; other wolf,⁹⁴ \$2; half is refunded to municipality by provincial treasurer.

⁹² *Manitoba:* The lieutenant governor in council may shorten the current open season on fur animals. Trapping in provincial game preserves prohibited.

⁹³ Chief game guardian may take necessary steps to prevent beaver damage, but no beaver dams may be disturbed between Oct. 1 and Apr. 1.

⁹⁴ Poison may not be used to capture wolves for bounty.

NEW BRUNSWICK

Open seasons:	Dates inclusive
Mink, otter, fisher, marten, sable.....	Nov. 1-Mar. 31.
Fox.....	Oct. 1-Feb. 28.
Muskrat (see exception).....	Mar. 25-May 1.
<i>Exception:</i> In Carleton, Gloucester, Kent, Madawaska, Northumberland, Restigouche, and Victoria Counties.....	
Beaver.....	Mar. 25-May 25.
Other fur animals.....	No open season. ⁹⁵

Prohibited methods: Unlawful to take fur animals by use of poisons, with aid of hounds, or with gun equipped with silencer; to dig out foxes from their homes or earth burrows; or to shoot muskrats.

Licenses: Trappers and fur dealers:⁹⁶ Persons domiciled in Province, \$10; all other persons, \$50. Trappers and fur dealers must furnish the minister with written declarations showing their names and addresses, the location of warehouses, shops, posts, or caches where skins are to be stored and the places from which the skins will be shipped out of the Province, and must make monthly reports of operations. Issued by minister of lands and mines. License is required to traffic in, cure, or tan skins: Resident, \$10; non-resident or resident alien, \$50; issued by minister. Special license (accompanied by necessary tags) to trap beavers at designated times may be issued by minister; fee, \$5 for each animal.

Possession and sale: Possession prohibited of furs on which royalties, as fixed by lieutenant governor in council, have not been paid; possession of green skins or carcasses of protected fur animals in close season prohibited.

Shipment and export: Skins legally taken, possessed, tagged, and on which the royalty has been paid, may be exported under permit from minister. Permit from minister required to export live fur animals.

Propagation: Permits to capture wild fur animals for propagation within the Province may be

obtained from the minister, who fixes the fee for such permit.

Bounties: Wildcat, \$3.

⁹⁵ *New Brunswick:* Expires Nov. 1, 1927.

⁹⁶ License requirements and other provisions of act do not apply to hunter or trapper who is a British subject domiciled and residing in Province, who actually hunts, provided he sells his furs to a person domiciled in the Province.

NORTHWEST TERRITORIES⁹⁷

Open seasons: ⁹⁸	Dates inclusive
Mink, fisher, marten.....	Nov. 1-Mar. 14.
Otter, beaver, muskrat (see exception).....	Oct. 1-May 14.
<i>Exception:</i> Muskrat, north of latitude 64°.....	
Foxes.....	Oct. 1-June 14.
Nov. 15-Mar. 31.	
Prohibited methods: Unlawful to use poison in taking fur animals or to destroy or injure any muskrat house or beaver dam or house.	
Licenses: Trapping: Resident, \$2; nonresident, British subject, \$75; other nonresident, \$150. <i>Fur dealer and trader or trafficker in furs:</i> Resident, \$5; nonresident British subject, \$150; nonresident not British subject, \$300. Issued by director of Northwest Territories. License not required of native-born resident Indian, Eskimo, or half-breed.	
Possession and sale: Licensed trapper may sell or trade the skins of animals he has legally taken. Possession of unprime or low-grade furs prohibited. No restrictions on other skins legally taken.	
Shipment and export: No restrictions on skins legally taken and possessed.	
Propagation: Permits may be obtained to take fur animals for propagation.	
Bounties: Timber wolf, \$30 (skin must be surrendered).	

⁹⁷ *Northwest Territories* means the northwest territories formerly known as Rupert's Land and the Northwestern Territory (except such portions thereof as are included in the Provinces of Ontario, Quebec, Manitoba, Saskatchewan, and Alberta, and the Yukon Territory), together with all British territories and possessions in North America and all islands adjacent thereto not included within any Province, except the Colony of Newfoundland and its dependencies.

⁹⁸ Trapping prohibited on Victoria and Banks Islands and in Peel River, Yellowknife, Slave River, and Backs River Preserves, which have been reserved as hunting and trapping grounds for native Indians, Eskimos, and half-breeds.

NOVA SCOTIA

Open seasons: ⁹⁹	Dates inclusive
Beaver, marten, fisher.....	No open season.
Bear, wolf, wildcat.....	Unprotected.
Other fur animals.....	Nov. 1-Jan. 31.
Prohibited methods: Unlawful to take any protected fur animal (unless under a permit) from a burrow or den by smoking, digging, or otherwise; to take fur animal by use of poison; to damage or molest a beaver dam or house or a muskrat house or to set snare or trap within 25 feet of the latter.	
Licenses: Trapping: None required of resident; nonresident, \$50; issued by Provincial secretary, commissioner of forests and game, and municipal clerks. <i>Fur buyers:</i> Nonresident, \$100; resident, \$5; resident traveling buyer, \$25; issued by commissioner. Fur buyer must keep record and make monthly report of number of skins bought or sold, together with names and addresses of parties from whom purchased or to whom sold. Royalties of varying amounts must be paid on all furs, except bear, wolf, and wildcat.	
Possession and sale: Unlawful to possess or sell the green hide of any beaver, fisher, or marten, or to possess the green hide of any fur animal taken out of season. No other restrictions on skins legally taken.	

NOVA SCOTIA—Continued

Shipment and export: Unlawful to export skins of fur animals except under certificate of inspection and permit (fee, 50 cents) from a game inspector.

Propagation: Permits (fee, \$1) to take wild animals may be obtained from the commissioner of forests and game under such restrictions as he may prescribe. Unlawful to keep fur-bearing animals in captivity for breeding purposes without a permit from the commissioner; fee, \$2 for each kind of animal kept, payable annually. Reports are required annually on December 31. Unlawful to trespass in inclosures for fur animals.

Bounties: None paid.

⁹⁹ *Nova Scotia:* Fox, raccoon, skunk, weasel, or muskrat may be killed on one's own inclosed premises for the protection of private property.

ONTARIO

Open seasons:¹⁰⁰ *Dates inclusive*
Mink, fisher, marten, raccoon... Nov. 1-Mar. 31.
Muskrat (see exception)..... Apr. 1-May 21.

Exception: South of French and Mattawa Rivers.... Mar. 1-Apr. 21.
Beaver, otter (see exception).... Dec. 15-Mar. 31.¹⁰¹
Exception: South of French River, Lake Nipissing, and Mattawa River.... Jan. 1, 1925.

Other fur animals..... Unprotected.

Prohibited methods: Unlawful to shoot or spear muskrat, to injure or destroy any muskrat or beaver house or beaver dam, or to set trap closer than 5 feet to a muskrat or beaver house.

Licenses: *Trapping:* Resident, \$5; nonresident, \$50; issued by department of game and fisheries. License not required to take bear or wolf by any means, or fox by means of gun or dog. Nonresident not permitted to take beaver or otter. Farmers and their sons may trap on own land during open season without license, except that a license is necessary to trap beaver or otter thereon (fee, \$11). Permission of owner required to trap beaver on lands of another. *Fur dealers or traders:* Resident British subject, \$25 (store license), \$100 (traveling fur buyer), \$100 (wholesale license); resident, \$1 (restricted—buying for personal use); alien or nonresident, \$200; nonresident, \$5 (buying from wholesalers); licensee must make reports monthly. *Fur dressing and tanning:* \$10; licensee must keep records and make monthly reports.

Possession and sale: Possession of furs during close season prohibited except during first 10 days under permit. Possession and sale of unprime skins prohibited, except under permit. Unlawful for trapper or farmer to sell beaver or other skins except to a licensed dealer. Unlawful to have skins dressed, plucked, or treated in any way except under permit obtained upon payment of royalties.

Shipment and export: Export prohibited except under permit obtained upon payment of royalties. No other restrictions on skins legally taken, possessed, or tagged. Shipments must be made by express or parcel post and packages must be marked with a list of the contents and the names and addresses of consignor and consignee.

Propagation: A permit is required of breeders of game or fur animals. Licensed fur breeders may sell five animals or skins during open season upon payment of royalties. The minister may grant permits to take fur animals for propagating purposes during the close season.

Bounties: Gray timber wolf, \$15; wolf pups under 3 months old, \$5; other wolf, \$10; paid by county, but Provincial treasurer refunds 40 per cent to the county. Provincial treasurer pays entire bounty in unorganized counties.

¹⁰⁰ *Ontario:* Fur animals may be destroyed in defense of property, but skins so taken may not be sold during close season except under permit from minister.

¹⁰¹ Beaver and otter may be taken by residents only. Under special permit from minister, overseer or other officer may take or kill beaver doing damage to roads or private property.

PRINCE EDWARD ISLAND

Open seasons: *Dates inclusive*
Otter, marten, mink, muskrat... Nov. 1-Mar. 31.
Beaver..... No open season.¹⁰²
Other fur animals..... Unprotected.

Prohibited methods: Unlawful to put out poisoned baits for fox or other animals.

Licenses: *Trapping:* None required of resident; nonresident, \$50; issued by secretary-treasurer of Province. The game warden may grant permits to take beaver and issue coupons (fee, \$1 each) to tag skins of animals taken.

Possession and sale: Possession and sale during close season prohibited. Holders of permits may possess, buy, or sell beaver skins which have proper coupons attached.

Shipment and export: No restrictions on animals legally taken, possessed, and tagged.

Propagation: Several special acts of the provincial legislature regulate fox ranching on the island. The animals are assessed for taxation, ranches are protected from trespass under heavy penalties, and incomes from ranches are taxed.

Bounties: None paid.

¹⁰² *Prince Edward Island:* Beaver may be taken under special license. They may be destroyed by the owner of private property on which they are locating and building dams, and, under permits from game warden or lieutenant governor in council, their dams may be destroyed when necessary to prevent damage to property.

QUEBEC

Open seasons: *Dates inclusive*
Bear..... Aug. 20-June 30.
Muskrat (see exception)..... Nov. 1-May 31.
Exception: South of 50th parallel..... Mar. 15-Apr. 30.
Fox..... Nov. 1-Feb. 28.
Beaver, otter..... Dec. 15-Apr. 30.
Other fur animals..... Nov. 1-Mar. 31.

Prohibited methods: Use of poisons in taking fur animals prohibited.

Licenses: *Fur dealers:* Persons domiciled in Province, \$25; all other persons, \$100; issued by minister of fisheries and game. Fur dealers must furnish the minister with written declarations showing their names and addresses, location of warehouses, shops, posts, or caches where skins are to be stored and the places from which such furs will be shipped out of the Province. This act does not apply to a hunter or trapper who actually hunts, if he is domiciled and resides in the Province and is a British subject.

Possession and sale: Persons engaged in buying, selling, or taking fur animals must, on or before the 10th of each month, make report to the minister. Unlawful to possess, buy, or sell skins of fur animals on which royalty has not been paid. No other restrictions on skins legally taken.

Shipment and export: Shipment and export prohibited, except of fur animals or furs on which royalties have been paid. Skins must be shipped open to view and each skin must be stamped to show royalty paid and be tagged as prescribed by the minister before being shipped in any manner. Packages must show names and addresses of consignor and consignee.

Propagation: The minister may grant permits to take animals alive for breeding purposes; nonresident license fee, from \$5 to \$25.

Bounties: Wolf, \$15.

SASKATCHEWAN

Open seasons:¹⁰³ *Dates inclusive*
Beaver (north of Township 52 only)..... Nov. 1-Apr. 30¹⁰⁴
Mink, fisher, marten, fox, lynx..... Nov. 1-Mar. 31.
Otter..... Nov. 1-Apr. 30.
Muskrat:¹⁰⁵
North of Township 52 (also Nov. 7 to Dec. 14)..... Mar. 1-May 14.
South of Township 53 (also Nov. 7 to Dec. 14)..... Mar. 1-Apr. 30.
Other fur animals..... Unprotected.

SASKATCHEWAN—Continued

Prohibited methods: Unlawful to use poison to take fur animals, to spear or shoot beaver or muskrat, or to destroy beaver dams or muskrat houses.

Licenses: Trapping: Resident, \$2; nonresident, \$25; resident licensee must return license on or before May 31 to chief game guardian with statement showing number of each kind of fur animals taken by him. *Fur dealer:* Resident, \$10; traveling agent for resident dealer: First permit, \$50, and \$10 for each additional permit. Nonresident, \$50; traveling agent for nonresident or nonresident traveling dealer, \$100; wholesale dealer, \$100.

Taxidermist: \$5; licensee must keep duplicate receipt book and furnish a copy thereof every 3 months to the minister. Issued by department of agriculture, Regina. Licensed fur trader must make annual report of operations. Resident treaty Indians may trap during open season without a license. Consent of owner or occupant required to trap on inclosed or cultivated lands of another. No license issued to person under 16 years of age without written consent of parent or guardian.

Possession and sale: Unlawful to buy, sell, or possess unprime pelts of protected fur animals.

Shipment and export: Packages containing fur animals must be plainly marked with full description of contents and names and addresses of consignor and consignee. Export of live fur animals prohibited except under permit of minister; fees, for black or silver fox, \$25; for cross or red fox or other live fur animal, \$5. Unlawful to ship unprime furs or to export any raw furs on which royalty has not been paid. No other restrictions on skins legally taken.

Propagation: Permit required (fee, \$1 annually) to operate a fur ranch. Permit to ship live fur animals is required; fee, for black or silver fox, \$25; for cross or red fox or other fur animal, \$5. Young foxes may not be taken from dens before May 15.

Bounties: Adult timber wolf, \$10; pups of prairie or timber wolf, \$1; paid only in properly gazetted wolf districts, when half is refunded from Provincial treasury.

¹⁰³ Saskatchewan: Trapping on game preserves prohibited.

¹⁰⁴ Beavers are protected on game preserves and south of Township 53.

¹⁰⁵ Minister may authorize the council of any municipality to destroy beavers or muskrats doing damage to highways or other public improvements.

YUKON

Open seasons: ¹⁰⁶	Dates inclusive
Beaver, otter (see exception).....	Jan. 1-June 30.
Exception: South of Arctic Circle.....	Jan. 1-May 15.
Marten.....	No open season.
Lynx, mink.....	Nov. 15-Apr. 1.
Muskrat (see exception).....	Jan. 1-June 30.
Exception: North of Arctic Circle.....	Dec. 1-May 31.
Fox (see exception).....	Nov. 15-Mar. 31.
Exception: South of Arctic Circle.....	Nov. 1-Jan. 31.
Other fur animals.....	Unprotected.

Prohibited methods: Use of poison, pitfalls, spears or similar devices prohibited, except that commanding officer, Royal Canadian Mounted Police, Dawson, may grant permits to poison wolves and other predatory animals. Traps must be taken up within 15 days after close of open season.

Licenses: Trapping: None required of resident; nonresident, \$100. *Fur buyer or dealer* (purchasing furs for sale or export): Nonresident, \$150; resident, \$25; mercantile establishment buying furs, \$25 (required for each place of business other

than head office); issued by gold commissioner or person designated by him.

Possession and sale: Skins legally taken may be possessed and sold at any time.

Shipment and export: Export of raw furs prohibited except under permit issued by direction of the commissioner, and upon payment of the export tax. Export of live fox prohibited. (See Propagation).

Propagation: Registration of fox breeders required. Unlawful to export a fox not born in captivity or which has been in captivity for less than a year; any fox born in captivity may be exported under a permit (fee, \$5). Fox and other fur ranches, if posted against trespass, may not be approached without owner's consent. No restrictions on other fur animals.

Bounties: None paid.

¹⁰⁶ Yukon: Commissioner in council may alter seasons.

Laws of Newfoundland

Open seasons: ¹⁰⁷	Dates inclusive
Otter, marten, lynx.....	Oct. 1-Mar. 31.
Fox.....	Oct. 15-Mar. 15.
Muskrat.....	Oct. 1-Apr. 30.
Beaver.....	No open season. ¹⁰⁸

Prohibited methods: Beaver house or dam must not be damaged by trapper. Use of poisons prohibited.

Bag limits: Twenty-five beavers in such localities as are opened by governor to trapping.

Licenses: Trapping: None required of resident except for beaver (beaver trapping license issued only to resident trappers of 3 years' standing); nonresident, \$501; issued by justice. *Fur buyer and shipper:* 50 cents; issued by game and inland fisheries board. Fur buyer must report operations semiannually on or before June 30 and December 31 of each year.

Possession and sale: No restrictions on skins legally taken, except beaver.

Shipment and export: (See Licenses.) Unlawful to export a live fox unless raised in captivity. No restrictions on skins legally taken, except beaver.

Propagation: No restrictions, except as to fox. A fox farm must be licensed; the owner must at stated times make reports to the game and inland fisheries board, and the premises must be at all times open to inspection by officers of the board. Possession of fox cub or fox taken in close season is prohibited. Unlawful to export a fox not bred on a fox farm, or without permit from the board, to export a fox bred in captivity.

Bounties: Crow, 20 cents.

¹⁰⁷ Newfoundland: Unlawful to trap on Grand Lake Caribou Preserves.

¹⁰⁸ Governor in council may proclaim open season on beaver in certain localities. Skins of beavers must be forwarded through magistrate to department of marine and fisheries, which has sole power to purchase or export.

Laws of Mexico

MEXICO ¹⁰⁹

Open seasons:	Dates inclusive
Beaver (male only).....	Nov. 1-Feb. 23.
No open season: Females and young of beaver.	
Licenses: Required for beaver: Resident, \$20; nonresident, \$40. Issued by Department of Agriculture and Development, Mexico City.	

¹⁰⁹ Mexico: For further information concerning trapping and fur laws, communicate with Director, Department of Agriculture and Development, Mexico City, Mexico.

Ind

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1446

COW-TESTING ASSOCIATIONS AND STORIES THE RECORDS TELL



FIRST-CLASS, profitable dairy farms are almost always found in groups. The center of each group is some farm, some man, some idea.

The 732 cow-testing associations now active in the United States are that many groups of improved dairy farms.

In nearly every case the association depends upon the activity of a few progressive farmers, and centers around the idea that every dairyman should know the individual records of his cows. Every dairyman needs to know what each cow is producing if he is to manage and develop his herd profitably. This knowledge can be obtained through cow-testing association records.

The purpose of this bulletin is to show the need and value of cow-testing associations, to present briefly some of the outstanding results obtained from a tabulation of cow-testing association data, and to show how such associations may be organized and conducted.

COW-TESTING ASSOCIATIONS, AND STORIES THE RECORDS TELL

By J. C. McDowell, *Associate Dairy Husbandman, Bureau of Dairying*

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LIKE A SEARCHLIGHT, the cow-testing association pierces the dense darkness that prevails so generally regarding the records of our dairy cows. In this penetrating and revealing light, production and feed-cost records stand out clearly. Only the scrub cow whose milk or butterfat production is scant need fear the light. Well may that cow dread the truth as told by the milk scales and the Babcock test, because when her record becomes known her doom is sealed and she must depart forever from the herd.

Far different is the fate of the large producer. She has no cause to fear the light. Through the work of the cow-testing association her high record stands out as it actually is, her true value becomes known, and in the dairy herd she takes her proper place. From that time on, if she is fed according to production, she will produce milk more and more abundantly. As the years roll around she may become the mother of a strain of high producers and persistent milkers, and unlike her distant relative, the scrub, she may remain for many years an honored member of the dairy herd—honored because profitable.

METHODS OF WORK

As ordinarily conducted in this country, a cow-testing association is an organization of about 26 dairy farmers, who cooperatively employ a tester to keep production, feed, and income records of their dairy cows.¹ Knowing the actual records of his cows, the dairyman can with certainty eliminate those that are unprofitable, and feed the remainder according to known production.

The most useful cow-testing association also compares the records of dams and daughters, promotes the ownership of better sires, encourages the use of proved sires, and shows the advantage of feeding satisfactory rations. This is a big program, but it is not too big for the well-organized and well-managed cow-testing association.

¹ A "Cow-tester's Handbook," Miscellaneous Circular 26, United States Department of Agriculture, giving details regarding the tester's work, may be obtained on application to the department. For information regarding the Babcock test, see bulletins published by the State agricultural colleges and the United States Department of Agriculture.

ACCURACY OF COW-TESTING ASSOCIATION METHOD

In the cow-testing association work the milk is ordinarily weighed and tested one day each month, and the monthly production is determined by multiplying the daily production by the number of days in the testing period. (Fig. 1.)

To determine the accuracy of the cow-testing association method of calculating production, the United States Department of Agriculture has compared the results of this method with actual yearly records, using 70 yearly individual-cow records of the Minnesota Experiment Station. These Minnesota records gave the production of milk and butterfat for each milking throughout the year. By systematically picking out the weights and tests for one day each month, as they would have been obtained by the cow-testing association method, and thus calculating the yearly production, it was found



FIG. 1.—The milk is tested once a month and the results recorded

that the association method was accurate within 2 per cent on milk production and within 3 per cent on production of butterfat.

A tabulation has also been made of 100 yearly individual-cow records from the department farm at Beltsville, Md. These records gave only the milk production night and morning for every day in the year. A yearly total calculated from one day's record each month, when compared with the actual milk production, showed an accuracy within 1.99 per cent. These comparisons indicate that the method used in cow-testing association work gives a very accurate record of production.

INCREASE IN NUMBER OF COW-TESTING ASSOCIATIONS

The first cow-testing association in the United States was organized in Newaygo County, Mich., in 1905, and the testing work was begun in January, 1906. Since then, with the exception of the two years, 1918 and 1921, there has been a rapid and fairly constant growth in the number of cow-testing associations. Table 1 shows

the number of associations on July 1 of each year from 1906 to 1923, inclusive, and on January 1, 1925. Figure 2 shows graphically how the number of these associations has increased during those years.

TABLE 1.—Number of cow-testing associations, 1906 to 1925, inclusive

Year	Associa- tions	Year	Associa- tions	Year	Associa- tions
1906.....	1	1913.....	100	1919.....	385
1907.....	4	1914.....	163	1920.....	468
1908.....	6	1915.....	211	1921.....	452
1909.....	25	1916.....	346	1922.....	513
1910.....	40	1917.....	459	1923.....	627
1911.....	64	1918.....	353	1925.....	732
1912.....	82				

The decline in cow-testing work in 1918 and again in 1921 was due largely to a shortage of trained testers. The number of associations in active operation January 1, 1925, was 105 more than on July 1, 1923. The map (fig. 3) shows that they are widely distributed throughout the United States.



FIG. 2.—How cow-testing associations have grown in numbers year by year

On January 1, 1925, there were 18,677 members in these associations, having 307,073 cows on test. As there are approximately 25,000,000 dairy cows in the United States, the number of cows now on test in cow-testing associations is a little more than 1 per cent of the total.

But what of the 99 per cent whose records are unknown? The man who does not know what each of his dairy cows is producing from a dollar's worth of feed is usually not in a profitable business. A man's progress in the dairy business is usually in direct proportion to his knowledge of the business. If testing pays, and it most certainly does, the work should be extended until many more than 1 per cent of our dairy cows are placed on yearly test.

RESULTS OF COW-TESTING ASSOCIATIONS

FIVE YEARS OF PROGRESS

In a well-managed cow-testing association the gain in average production per cow is quite rapid during the first four or five years of association work. In the case of three particular associations—one in Michigan, one in Ohio, and one in Pennsylvania—the average production of butterfat per cow during the first five years of testing showed a gain each year in each association. For the three associations when averages were combined, the yearly butterfat production per cow was as follows: First year, 237 pounds; second year, 255 pounds; third year, 278 pounds; fourth year, 292 pounds; and fifth year, 305 pounds.

What the average butterfat production was during the year before the work began there is no means of knowing, but in many of the herds it probably was about the average production for all the dairy cows in the United States, which is estimated to be about 170 pounds a year. Therefore it seems reasonable to conclude that the cow-testing association work has practically doubled the average production of butterfat per cow in these three associations. The figures just given are normal for the well-managed cow-testing association, but there are many associations where the gains from year to year are not so great.

Every cow-testing association member should watch the production figures of his cows, and he should not be satisfied unless there is a rapid gain in average milk and butterfat production every year until the herd reaches a high level of production. Even then he should not be satisfied with less than at least a small gain in production per cow from year to year.

HELPS BOTH HIGH AND LOW PRODUCING HERDS

The cow-testing association work helps both low and high producing herds. When the first Minnesota cow-testing association was started near Albert Lea in 1910 the lowest-producing herd on test consisted of 30 cows whose average production was 2,958 pounds of milk and 112 pounds of butterfat. That year the butterfat did not pay the cost of feed. Four years later there were 20 cows in the same herd; their average production was 4,759 pounds of milk and 228 pounds of butterfat, and the average income over cost of feed was \$50. In four years' time the average butterfat production per cow in that herd was more than doubled, resulting in a substantial income over cost of feed.

The first year the highest-producing herd in that association consisted of 22 cows whose average production was 9,390 pounds of milk

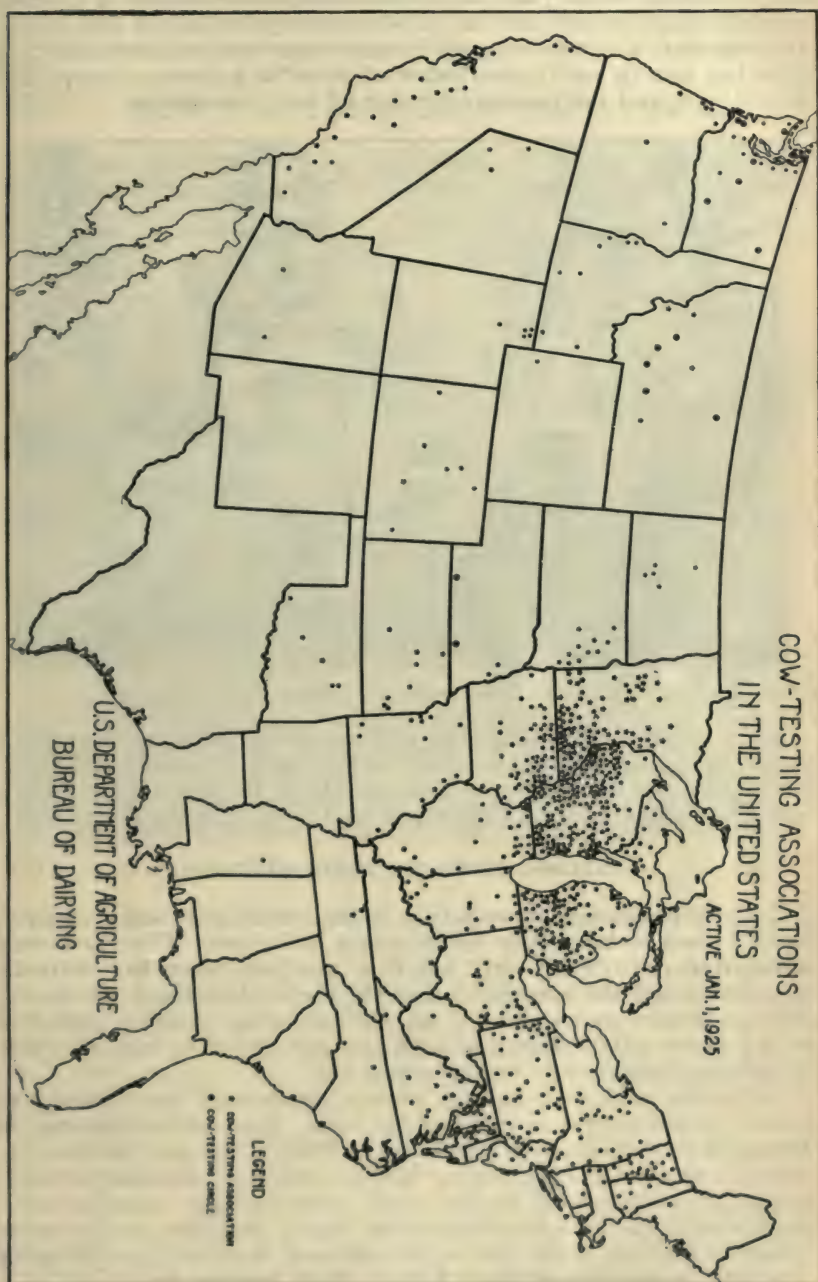


FIG. 3.—Location of cow-testing associations

and 311 pounds of butterfat, and the average income over cost of feed was \$52. Four years later the same herd consisted of 25 cows whose average production was 11,948 pounds of milk and 400 pounds of butterfat, and the average income over cost of feed was \$98. Here is a gain in yearly production of butterfat per cow of more than 28 per cent, and the income over cost of feed was almost doubled.



FIG. 4.—Their records tell a pleasing story

These figures show that the work of the cow-testing association improves high-producing herds as well as those of lower quality. In both cases the results were brought about through selection and breeding, better feeding, better care, and better management.

SELLING COWS ON THEIR RECORDS

Reliable production records help in the sale of good stock. Buyers usually want to know how much milk a cow gives. The cow-testing association records not only tell this, but they show her butterfat production and the amount of feed she ate while making the record. Anyone would pay more for an animal whose yearly production record shows 10,000 pounds of milk and 450 pounds of butterfat than if nothing definite were known about her.

At public sales cow-testing association records have sometimes greatly raised the prices received for cows. Association sales may be arranged in some cases to advantage. When a sale can be arranged among a number of neighboring farmers it is possible to attract more buyers and thus obtain for the cattle what they are actually worth. Such a sale has an advantage to the buyer also, because he knows where to find the stock that is for sale and does not have to spend time and money driving from farm to farm looking for it.

The cow-testing association records may be used to advertise the dairy herds of the community. Each month the tester may publish

an honor list composed of the largest-producing cows. This list, together with the names of the owners, may be published in the local papers and in the farm journals. Further publicity may be obtained at reasonable cost through the use of cooperative advertisements.

HOW FARMERS REGARD THE WORK

One farmer says that at the beginning of his first year in a cow-testing association he knew he was making no money, but he did not know why. He says that at the end of the testing year he still knew he was making no money, but by that time he knew why. He is now the owner of a high-producing and profitable dairy herd.



FIG. 5.—Scrub herd. This herd is unprofitable—and does the owner know why?

When another farmer joined a cow-testing association he was the owner of 14 cows. The first year's records showed that 7 of his cows were very profitable and that 7 were decidedly unprofitable. This farmer says that his herd reminded him of the Hebrew-Egyptian story of the 7 fat years and the 7 lean years, for as the 7 lean years ate up the 7 fat years, so his 7 poor cows ate up the profits the 7 good cows made. When that farmer signed up for a second year in the cow-testing association he was the owner of a smaller but better herd.

The following quotations are from what farmers have said regarding cow-testing association work:

The first year I belonged to the association my herd of 10 cows produced an average of 279 pounds of butterfat, with an average income over cost of feed of \$37. The fifth year my herd, which then consisted of 17 cows, produced an average of 380 pounds of butterfat with an average income over cost of feed of \$82.

The work of the cow-testing association has increased the cream checks about \$250 a year on my 12 cows.

It is the best-paying investment I ever made.

By doing away with guesswork one can triple his profits and lessen his labor.

The association culls the boarder cows and advertises the good ones.

I found that my best cows were producing butterfat at a third the cost of the poorest one.

I offered to sell a cow for \$75 before testing. She made 495 pounds of butterfat. I would not sell her now.

The cow-testing association has added at least \$25 a head to all the cattle I have sold.

The association has greatly improved the social life of the community.

What a change since the association was organized. Now we cooperate in buying feed, in hauling cream, and in holding public sales of tested cows. Every member grows alfalfa, keeps a purebred dairy sire, and raises the best of the heifer calves.



FIG. 6.—She foraged on the very best of pastures

A VIRGINIA EXPERIENCE

Seven years ago a certain Virginia farmer was a member of a cow-testing association. He was the owner of 91 cows, and during that year he discovered that many of them were naturally very low producers. To make matters worse, careless hired men dished up the grain with a scoop shovel and fed all the cows alike regardless of production. As might be expected under those circumstances, production was low, feed cost was high, and income was low.

Each year since then the cow-testing association work has improved that herd, which has been reduced from 91 cows to 54. Milk production has advanced from 3,311 pounds per cow to 5,953. Butterfat production has advanced from 155 pounds per cow to 280. But most marvelous of all, the income over cost of feed has jumped from 64 cents to \$146.07 per cow per year—more than 200 times as

much. This increase in income over feed cost was due to better cows, better feeding, and to better marketing of the product.

Last year the average cow in the herd produced more income over cost of feed than was produced by the 91 cows seven years ago. In fact it would require 228 cows like those in the original herd to produce as much income over cost of feed as is produced by the average cow in that same herd to-day. Needless to say, the owner is a firm believer in the work of the well-managed cow-testing association. (See fig. 4.)

HOW MOLLY'S LIFE WAS SAVED

A grade Guernsey cow named Molly lived on a beautiful dairy farm near the city of Baltimore. She

drank pure fresh water from a sparkling upland stream, and all summer she foraged on the very best of pastures. (Fig. 6.) She did not know that her owner was ignorant of the quality of the milk she gave, nor that he thought the quantity rather small. She did not



FIG. 7.—Her owner telephoned to a cattle dealer



FIG. 8.—Her owner joined a cow-testing association

know that he had telephoned to a cattle dealer telling him to come and get a certain cow named Molly. (Fig. 7.)

The dealer agreed, but delayed his coming. About that time the county agent and the dairy extension field man induced Molly's owner to join a cow-testing association (fig. 8), and one day the tester weighed and tested Molly's milk. (Fig. 9.) The test showed 5.5 per cent butterfat and the tester advised that Molly be kept a little longer, because her milk more than made up in quality for what it lacked in quantity.

Before that testing year had run its course Molly had proved herself a high tester and persistent milker. Her daily yield was never large, but the total for the year was 5,967 pounds of milk, containing 330 pounds of butterfat. In production of butterfat Molly ranks among the highest in that herd.



FIG. 9.—Testing Molly's milk

WHAT COW-TESTING ASSOCIATION RECORDS REVEAL

BETTER COWS NEEDED

In most sections of this country we have enough cows, but not good enough cows. Our slogan should not be "More Cows" but "More *Good Cows*." Here is one place where there is an abundance of room at the top.

In the Newaygo County, Mich., cow-testing association the herd that one year had the highest average production of butterfat per cow consisted of 10 cows and the herd that had the lowest average production consisted of 20 cows. The herd of 10 cows had a total income over cost of feed of \$666 and the herd of 20 cows \$455. The owner of the larger herd needed 9 more cows of the kind he was keeping to get as much income over cost of feed as was produced by the smaller herd.

It is better, however, to own 10 good cows than 29 poor ones. It demands less labor and other costs. To build up a herd of 10 good cows (fig. 10) requires much headwork. To take care of a herd of 29 poor cows requires much handwork. The dairyman who does not use his head must work that much harder with his hands.

FEEDING FOR PROFIT

A tabulation of more than 21,000 yearly records of cow-testing association cows has shown that on an average the high producers of

milk and butterfat consumed more dollars' worth of feed per cow than the low producers, but they also yielded a higher income over cost of feed.

In one association the herd that ate next to the least in dollars' worth of feed per cow produced on an average the least milk and the least butterfat, and paid the lowest gross income per cow and the lowest average income over cost of feed. In that association the herd that ate the most in dollars' worth of feed per cow produced the most milk and the most butterfat on an average, and paid the largest gross income per cow and the largest average income over cost of feed. In every large tabulation which the writer has made, the group of highest-producing cows ate the most in dollars' worth of feed per cow, but they produced the most milk and butterfat and had the largest average income over cost of feed. Evidently it pays to feed good cows well.



FIG. 10.—To build up such a herd requires testing, not guess work

The dairy cow may be considered as a feed market. The low-producing cow pays a low price for feed and the high-producing cow pays a high price for feed. A tabulation of more than 21,000 yearly individual-cow records showed an average return of \$2.13 for every dollar spent for feed. The returns varied from less than \$1 to a little more than \$3. The cow that returns a dollar for a dollar's worth of feed is a very poor feed market, but the cow that returns \$3 for \$1 worth of feed is a very good feed market. The cow-testing association herd book, completely filled out and posted up to date, is one of the best feed-market reports the dairyman can have. It tells him how many dollars' worth of feed Spot, Daisy, and the rest of his cows are eating, also how much each cow is paying for her feed.

GOING UP OR COMING DOWN

The cow-testing association records show that some herds improve from year to year and that others do not. This was demonstrated in the case of two herds that were on test continuously during the first four years in one association. The results are shown in Table 2.

TABLE 2.—Average butterfat production per cow per year in two herds of the same association

	Herd A	Herd B
First year.....	377	234
Second year.....	350	244
Third year.....	321	302
Fourth year.....	313	315

When the work began herd A excelled herd B in butterfat production by a margin of 143 pounds per cow. In each successive year herd A went down and herd B went up in yield per cow, until the fourth year, when herd B produced a trifle more butterfat per cow than herd A.

These figures show that membership in a cow-testing association helps but little unless the lessons are put into practice. The owner of herd A should find out why the average butterfat production in his herd is gradually coming down, and he should find some means to face his herd the other way. The owner of herd B is doing very well. The average production of his herd is going up, because he is weeding out the poor cows, and feeding the remaining ones better. He should do his best year by year to push the average still higher. No dairy herd has ever dropped so low that culling, feeding, and breeding could not build it up, and no herd is yet so high that these three factors can not lift it higher. The cow-testing association records tell the true story and show whether the records are going up or down.

A DAIRY DEAD LINE

The question is often asked: When should a dairy cow be condemned because of low production? That is an easy question to ask, but not so easy to answer.

According to estimates of the United States Department of Agriculture, the average yearly production of our dairy cows in 1923 was 4,260 pounds of milk. Certainly no one will contend that a mature cow whose production is below that level should long be kept on a dairy farm. A tabulation of more than 21,000 yearly records of cow-testing association cows has shown an average yearly production of 6,077 pounds of milk and 248 pounds of butterfat per cow. Many dairymen feel that a level of 6,000 pounds of milk and 240 pounds of butterfat per cow per year should be required of every mature cow in the herd.

Many a good cow has lost her life because her owner did not know what she produced. Many a good cow's life is still in danger because her owner does not keep production and feed cost records of his cows. It is easy to place the dead line at 6,000 pounds of milk and 240 pounds of butterfat a year, but it is not so easy to bring the record of every mature cow above that line. Culling, alone, will not do it without too much killing. Culling and feeding, together, will not do it without too much killing and too much cost. But culling, feeding, and breeding, all combined, will do it, and do it at a cost that ordinarily will leave a fair net profit.

DRY TOO MUCH OF THE TIME

In a Mississippi cow-testing association, during the testing year 1921-22, one cow produced milk 7 months, with a butterfat production of 79 pounds and an income of \$7 over cost of feed. Another cow produced milk 11 months, made a butterfat record of 313 pounds, and an income over cost of feed of \$64. In dollars' worth of feed the higher producer ate more than twice as much as the other cow, but she produced four times as much butterfat and nine times as much income over cost of feed. The good cow was a persistent high producer; the other was a very low producer. Even during the period when she was fresh she was a low producer, and she was dry too long.

A tabulation of more than 10,000 yearly individual-cow records from testing associations showed that on an average those cows remained in the herd 4.7 years from the time they reached production age. Similar studies of records by the Office of Farm Management of the United States Department of Agriculture,² and by C. W. Larson³ gave 4.43 years and 4.85 years, respectively. Figures from these and other sources indicate that on an average dairy cows remain in the herd less than 5 years from the time they reach production age. If that is true, the average dairy cow has already lived about one-third of her life before she directly pays a single dollar for her stable room and board. In other words, she lives $2\frac{1}{2}$ years out of $7\frac{1}{2}$ before she produces any dairy products. If during her 5 productive years she is dry 3 months in every 12, she is dry $1\frac{1}{4}$ years of the 5. Two and one-half plus one and one-fourth equal three and three-fourths, exactly one-half of the entire lifetime of the cow.

If our dairy cows freshened once a year on an average, which at present they do not, and if each were a persistent high producer, their productive lifetime in the herd might be 10 years instead of 5 and their income over cost of feed during all the years would be several times what it is now.

A high-producing cow begins to yield a profit at the age of 2 or 3 years. When she is 6 and 7 years of age the profits from her are very high and she may continue to yield a profit until very late in life. (Fig. 12.)

The lifetime records of a low-producing cow may be likened to the daily course of the winter's sun, which rises late, remains low, lasts only a little while, then disappears. The lifetime record of a high-producing cow may be likened to the daily course of the summer's sun, which rises early, climbs to a great height, remains long, descends slowly, and seems reluctant to disappear.



Fig. 11.—A scrub cow. Her owner is patient. The cow-testing association shows how unprofitable she is

² Department Bulletin 341, United States Department of Agriculture, Farm Management Practice of Chester County, Pa., p. 95.

³ Milk Production Cost Accounts, Principles and Methods. Columbia University Press, 1916.

WHEN COWS SHOULD FRESHEN

A tabulation of 10,870 yearly records of cow-testing association cows showed that those cows which freshened in the fall and early winter did better in production of milk and butterfat and in income over cost of feed than those which freshened in the spring and



FIG. 12.—Her record is as persistent as the summer's sun

summer. Those that freshened in the fall and winter produced 11 per cent more milk, 11 per cent more butterfat, and 11 per cent more income over cost of feed than those that freshened in the spring and summer.

While fall and winter freshening won on an average, they did not win on every farm or in every association. The influence of date of freshening appears to be a local problem for which no set rule can be given.

COW-TESTING MEASURES BULL-ASSOCIATION WORK

The cow-testing association records determine the true value of bull associations. In the vicinity of Grove City, Pa., there are two



FIG. 13.—Following in the footsteps of her mother

bull associations and one cow-testing association. From that district we now have the yearly records of daughters of bull-association bulls and the yearly record of the dam of each daughter.

When all records were figured to maturity, it was found that on an average the dams produced 8,785 pounds of milk a year and the daughters 9,212 pounds. The dams averaged 355 pounds of

butterfat a year and the daughters 394 pounds. Thus the daughters produced about 5 per cent more milk and about 11 per cent more butterfat than their dams. That percentage of gain seems small until we realize that the daughters were matched against no ordinary dams. The figures further showed that the daughters were by six bulls, and that in no case did the daughters bring discredit to their sire.

What would have happened if the 18 daughters had been sired by scrub bulls or by inferior purebred bulls is not hard to guess. The fact, learned from cow-testing association figures, that the daughters of these bulls surpass their high-producing dams by 5 to 11 per cent proves conclusively that the bull association is a great success.

HOW TO START AND CONDUCT AN ASSOCIATION

STARTING THE ORGANIZATION

After a community has become convinced of the need of having a cow-testing association, the next step is to organize. A meeting may be called and a temporary organization effected. The neighborhood is thoroughly canvassed until about 26 dairymen have agreed to become members. Another meeting is then called and a permanent organization formed. Officers are elected and a constitution and by-laws adopted.

The best experience shows that this work should be done under the direction of the dairy extension specialist and the county agent, and with the full cooperation of all local agencies.

In this bulletin is a draft of constitution and by-laws. These indicate a form of organization that will give satisfaction and meet the needs of most associations. Whatever adaptations are necessary to fit them to local needs and desires can readily be made.

The county agent, the State agricultural college, or the Bureau of Dairying of the United States Department of Agriculture, will on application furnish copies of the constitution and by-laws, also copies of the form to be used in making a contract between the association and the tester.

COST

Enough money must be raised each year to pay the tester's salary, which is usually somewhere between \$75 and \$100 per month, and to provide for the incidental expenses connected with the work. The testing outfit, costing about \$50 must be purchased the first year. An additional \$50 should pay for the sulphuric acid, breakage, record blanks, publicity, and all other incidental expenses necessary for the work for a year. The entire cost, including the board of the tester and his transportation from farm to farm, is not high for each member of the association. Generally the cost is distributed so that the owners of large herds pay more than the owners of small herds.

TESTING OUTFIT

The testing outfit consists of the following: Milk scales, Babcock tester and glassware, sample jars, sample dipper, test-bottle bath,

drainage rack, supply of commercial sulphuric acid (specific gravity of 1.83), a set of computing tables, a suitable box with lock to hold the apparatus and to keep milk samples until they are tested.

SELECTING A TESTER

As a rule the members of the association must rely largely on the State agricultural college when it comes to the selection of a competent tester.

The tester should have some special training in testing in addition to farm experience. The more he actually knows about selection, feeding, and constructive breeding of dairy cattle, the greater will be the value of his services to the association. It is essential that he be a man of good habits, and neat and clean in every way. He must be the type of man that will be welcome in the homes of the community, because it is in these homes that he must live while working there.

The farmers, however, must not expect too much of the cow tester. He is there primarily to weigh and test the milk, to weigh the feed, and to keep complete and accurate records of the work. He may also advise the members of the association regarding the feed and care of each cow in the herd. He can not work miracles. He can not by any method of feeding get a yearly butterfat production of 300 pounds from the cow with ability to produce only 100 pounds.

WORKING WITH THE TESTER

The tester can be of great service if all the members of the association will work with him toward the building up of better herds of dairy cattle. The wide-awake tester is a willing worker. He begins his day in the early morning and continues until the milking is done at night and the samples are all put away under lock and key. He weighs the feed, weighs and tests the milk, and keeps the records constantly up to date. He is ready at all times to interpret the figures to the best of his ability and to work with the farmers in studying out better methods of feeding, care, and management. To do all this and do it well, he must have the cooperation of the farmers in the association.

THE TESTER'S WORK

The tester visits each farm one day each month. Usually he arrives in the afternoon. That evening he weighs the feed, weighs the milk, and takes a sample of the milk for testing. He records all figures in the barn book, from which he transfers them to the herd book. The barn book is the tester's record of the work, and the herd book remains in the possession of the farmer as his record of the work. The next morning the tester again weighs the feed, weighs the milk, and takes a sample of the milk for testing. He thoroughly mixes the two samples of each cow's milk, and then tests the composite sample for percentage of butterfat.

From the herd book the farmer can at any time get the record of his herd, and of each cow, for each month from the beginning of the testing year to date. He can also get totals to date for each and every cow. The herd records include feed cost and production of

milk and butterfat. The individual-cow records include all this and in addition they give the feed in pounds for each kind consumed.

At the end of the testing year the farmer can get from the herd book the yearly summary of his herd and of each cow. As the years pass he can compare the yearly records and determine what progress his herd is making and what progress each individual cow is making. If the herd books are carefully and completely filled out, the farmer can get all this information very quickly and from this knowledge of the records of his cows he can go forward, without guesswork, in the improvement of his herd. With a well-kept herd book the farmer is able to build up his herd quickly through intelligent selection, breeding, and feeding.

HOW TO OBTAIN COMPLETE RECORDS

The question is sometimes asked: How can testers be induced to fill out the records accurately and completely at the end of the testing year? It has been found in practice that it is not advisable to hold back part of the tester's salary until he turns in his records properly filled out, as that is a penalty which antagonizes the tester and results in hard feelings to no purpose. A better way is to offer the tester a bonus to be paid when he does fill out the records in proper form. He will work harder to obtain a bonus than to avoid a penalty. With the offer of a substantial bonus for the satisfactory completion of the year's work by the tester, it is believed that every tester will be induced to turn over to the State and to the United States records of the highest value, and that by so doing each tester will better serve the interests of the farmers who belong to the local association.

MILKING AT REGULAR TIMES

Many farmers weigh the milk of each cow at every milking. This enables them to detect any gain or falling off in milk flow and to feed according to milk production. By the use of the milk scales, if the milking is done at the same time every day, the dairyman can readily determine which of his cows are responding to better feed and care. It is especially important that the milking should be at regular times on the day the tester is there and the day before he comes, because the total production for the monthly testing period is usually calculated entirely from the records made the day the tester is on the ground. There should be no temptation on the part of the farmer to inflate the records through irregular milking periods, because the primary purpose of cow-testing association work is to let the farmer himself know the true production and feed-cost records of his cows. Knowing these records he can select, breed, and feed intelligently.

COMMUNITY DEVELOPMENT

One of the most valuable advantages of organized cow testing is the development of the community. The farmers of some associations get together once a month to discuss the business of the association and to exchange ideas regarding better methods of dairying. Sometimes these meetings take the form of an automobile tour, a summer picnic, or a field day, and a definite program is carried out.

Make the program entertaining and inspirational as well as educational. It should be made so interesting and valuable that all who come this year will want to come next year. In discussing cow-testing association records, herds should be referred to by number rather than by name.

Placing some of the best cows on exhibition will add interest to the meeting. A judging demonstration or judging contest will generally appeal to most of the people present. An automobile trip to some of the best dairy farms of the community has been tried out and has proved to be valuable and profitable. This trip enables the farmers to see the best cows belonging to members of the association and to observe the methods of the best farmers in the community.

PRODUCTION AND INCOME

HOW THE INCOME CLIMBS

High-producing dairy cows are profitable cows. In a tabulation of more than 18,000 yearly records of cows in testing associations, where the income was from the sale of butterfat, the group of cows having an average yearly butterfat production of 100 pounds made an average income of \$10 over cost of feed. At 200 pounds of butterfat a year the income over cost of feed was \$42; at 300 pounds it was \$74; and at 400 pounds it was \$106. This does not mean that every cow that produces 400 pounds of butterfat a year will give an income over cost of feed of \$106, but it does mean that this is the relative advantage and that under normal conditions such a cow is many times more profitable than the one that produces only 100 pounds of butterfat.

This study covers the period 1910 to 1920, inclusive, and includes records from various parts of the United States. The feed cost and income figures vary for different years, for different prices, and for different geographical districts. For example, in the leading dairy districts, a cow that produces 100 pounds of butterfat a year does not ordinarily yield an income over cost of feed; yet in some of the less developed districts where feeds are cheaper such cows may return a small income above feed cost.

On an average, 1 cow in the 400-pound group produced more income over cost of feed than 10 cows in the 100-pound group. Most dairymen would rather take care of 1 good cow than 10 poor ones, yet in many of our dairy herds the 100-pound cows are much more numerous than the 400-pound cows. It is almost incomprehensible that any dairyman will continue to care for low-producing, unprofitable cows in his herd year after year when there are so many other and more worthy objects of charity.

As average butterfat production per cow increased, from group to group, the gain in income over cost of feed was very regular. As a rule, a gain of 50 pounds in production of butterfat per cow was accompanied by an increase of \$16 in income over cost of feed. The figures also showed that very few cow-testing association cows are fed beyond the point of economical production. The figures invariably showed that the highest-producing group was the most profitable group of dairy cows.

THE COST OF KEEPING SCRUBS

The average yearly butterfat production of all the dairy cows in this country has been estimated at about 170 pounds. The exact figures are unknown. Assuming that the average production is 170 pounds and that half the dairy cows are below average we bump up against the astounding fact that we are feeding good hay and grain and pasture to 12,000,000 low-producing dairy cows. It costs about \$600,000,000 to feed these cows and about \$600,000,000 more for labor and for overhead expenses. We go to all this trouble and expense, and our only tangible return is barns full of unprofitable dairy cows. If the cow-testing association eliminates the scrubs and establishes well-fed, well-bred, high-producing cows on every dairy farm it will have accomplished its chief purpose. Even then, however, its work will not all be done, because these higher standards must be maintained.



FIG. 14.—A high-producing group. But testing will show big differences in their records

POWER IN ACTION

To get anything out of cow-testing association work the dairyman must make use of the information obtained from a careful study of the records. If he does this, the records will be a gold mine of useful information to him. From his knowledge of the records of dams and daughters the dairyman can determine definitely what progress his herd is making due to breeding. From his knowledge of production and feed-cost records he can, without guesswork, eliminate all cows that do not yield a profit, and he can feed the remainder according to their known production. As the years pass he can eliminate all cows except those that yield large returns; and gradually, but certainly, he can build up a herd of high-producing, profitable dairy cows.

CONSTITUTION AND BY-LAWS FOR THE COOPERATIVE COW-TESTING ASSOCIATION

(As adopted by the cow-testing association committee of the American Dairy Science Association)

CONSTITUTION

ARTICLE I.—NAME

The name of this association shall be the ——— Cow-Testing Association.

ARTICLE II.—OBJECT

The object of this association shall be to provide means and methods for improving the dairy herds of members. This will be accomplished through the keeping of production, feed, and income records of each cow, on the basis of which unprofitable cows may be eliminated and feeding done more economically.

ARTICLE III.—PLACE OF BUSINESS

Its principal office and place of business shall be at ———.

ARTICLE IV.—MEMBERSHIP

This association shall be composed of dairymen or owners of dairy herds who agree to comply with the members' agreement, and who are acceptable to the board of directors.

ARTICLE V.—MEETINGS

This association shall meet annually for the election of a board of directors and for the transaction of other necessary business at such time and place as may be determined upon by the board of directors. All members shall be notified at least one week in advance of such meetings. Special meetings of the association may be called by the president or the board of directors, notices thereof at least two days in advance to be given to all the members of the association. Meetings of the board of directors shall be called by the secretary on the order of the president or three members of the board.

ARTICLE VI.—ORGANIZATION

The governing body of this association shall consist of a board of directors composed of five active members, who shall elect from their own number a president, vice president, secretary, and treasurer, whose duties shall be those usually devolving upon such officers. The first election of officers shall be held immediately after the election of the board of directors. All officers and directors shall hold office until their successors are elected. Vacancies occurring in the board of directors shall be filled by a majority vote of the remaining members of the board.

ARTICLE VII.—BUSINESS

Authority to conduct the business of the association shall be vested in the board of directors.

ARTICLE VIII.—ELECTION

Election of all officers and directors shall be by majority vote.

ARTICLE IX.—AMENDMENTS

This constitution may be amended by a two-thirds vote of the active members of the association present at any annual meeting.

BY-LAWS

ARTICLE I.—ORDER OF BUSINESS

1. Reading of minutes of previous meetings.
2. Reports of secretary and treasurer.
3. Reports of committees.
4. Unfinished business.
5. New business.
6. Election of officers.

ARTICLE II.—QUORUM

Three members of the board of directors shall constitute a quorum.

ARTICLE III.—AMENDMENTS

The by-laws may be amended by a two-thirds vote of the active members of the association present at any annual meeting.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

May 1, 1925

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<i>Assistant Secretary</i> -----	R. W. DUNLAP.
<i>Director of Scientific Work</i> -----	E. D. BALL.
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This bulletin is a contribution from

Bureau of Dairying----- C. W. LARSON, *Chief*.

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1447

CITRUS FRUIT
GROWING
IN THE
SOUTHWEST



THE COMMERCIAL DEVELOPMENT of the citrus industry in the Southwest is founded upon the success of the Washington Navel orange, which was sent to Riverside, Calif., in 1873 by the United States Department of Agriculture. At the present time more than 270,000 acres are devoted to the growing of oranges, lemons, and grapefruit, and the normal crop shipments exceed 60,000 carloads.

The recent rapid growth and success of the industry has been made possible by the utilization of the results of scientific research along many lines. New methods of propagation, orchard development, frost protection, pest control, and handling and transporting the crop have been originated and introduced which have not only made possible the profitable production of citrus fruits in the Southwest but have also been found to be fundamentally important in the production and marketing of other fruit crops throughout the country.

Citrus growing in the Southwest, far from the market centers, is a specialized complex business in which the operator, to be successful, must have foresight, abundant energy, and a belief in his work. To these he must add a personal interest and constant attention to details. Growers who neglect their orchards learn that they are operating at a loss, but those who give sufficient food, water, and work find their balances on the right side of the ledger.

CITRUS FRUIT GROWING IN THE SOUTHWEST

By A. D. SHAMEL, *Physiologist*, C. S. POMEROY, *Pomologist*, and R. E. CARYL, *Assistant Pomologist*, Office of Horticultural Investigations, Bureau of Plant Industry

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INTRODUCTION

THE COMMERCIAL GROWTH of citrus fruits in the southwestern United States is limited to districts in California and Arizona. While oranges doubtless have been grown in California for about 150 years, the extensive development of the industry has taken place largely within the last 30 years, and there is still a great diversity of opinion among growers regarding the most successful methods of conducting some of the fundamental practices of the business. Public agencies and many growers are engaged in investigations of various citrus problems, and improved methods of culture and orchard management are continually being developed as a result of this experimental work.

Various phases of some of these improved practices have been discussed in the horticultural press and announced through bulletins or at meetings of fruit growers, but there is no general treatise on citrus culture which includes many of the recently adopted methods of conducting a number of important orchard operations. The present bulletin is intended to supply this lack, in order that the established citrus growers may have the benefit of such knowledge and that the newcomer may have reliable information as to the most dependable methods to be followed in caring for an orchard.

Citrus growing in Arizona has only recently become of commercial importance, and many cultural practices have not been thoroughly tested there as yet; hence the methods described in the following pages must of necessity deal largely with California conditions and the developments which have followed the growth of the industry in that State. However, the fundamental principles underlying successful citrus culture in California apply generally to the conditions in the Southwest as a whole.

DEVELOPMENT OF THE INDUSTRY

It is impossible to determine the date when oranges were first planted in California or Arizona, but it is certain that scattering trees were grown at some of the first Franciscan missions which

were founded in California in the latter part of the eighteenth century. Orchards and vineyards were established at all these missions, being propagated from plantings at the older missions in Lower California. Trees and vines from these early plantings were set in many private gardens, and the Mission olive, Mission grape, Mission fig, and orange seedlings from the mission grounds formed the basis for the first commercial developments in fruit growing in the Southwest.



FIG. 1.—One of the two parent Washington Navel orange trees planted at Riverside, Calif., in 1873, from which most of the trees in the California and Arizona Washington Navel orchards have descended. (Photographed in May, 1922)

DEVELOPMENT IN CALIFORNIA

The nucleus of the present California citrus industry doubtless was formed at the San Gabriel Mission, near Los Angeles, in 1804 or 1805, when about 400 seedling trees were planted in an orchard of 6 acres for the use of persons connected with the mission. The first commercial orange orchard is believed to have been started by William Wolfskill at Los Angeles in 1841. By 1870 small scattered

plantings in many parts of the State had demonstrated that much of the foothill territory from San Diego to Butte County was suitable for citrus culture.

The beginning of the commercial development of the California citrus industry is considered as dating from the completion of the Southern Pacific Railroad from Oakland to Los Angeles in 1876, which opened the way for direct shipments out of the State. The opening of the Southern Pacific line to New Orleans in 1881 and the completion of the Santa Fe Railroad in 1885 gave added stimulus for further commercial plantings. Another important factor in the upbuilding of the industry was the fruiting of the Washington Navel orange at Riverside about 1878, when this variety was found to be much superior to any then grown. One of the two trees of this variety which were sent to Riverside from the United States Department of Agriculture in 1873 is shown in Figure 1.

The region in which citrus fruits are now commercially grown in California is an extensive one, reaching from the northern part of Glenn County to the southern part of San Diego County, a distance of about 550 miles from north to south and varying in width from 3 to 75 miles. This general region is subdivided geographically into three sections: (1) Southern California, including the coast regions from San Diego to Santa Barbara, the valleys of the Santa Ana and San Gabriel Rivers, and plantings in the Coachella and Imperial Valleys, these districts representing San Diego, Orange, Los Angeles, Ventura, San Bernardino, Riverside, Santa Barbara, and Imperial Counties; (2) central California, comprising the plantings along the foothills of the Sierras, mainly in Kern, Tulare, and Fresno Counties; and (3) northern California, where less extensive plantings are found in Glenn, Butte, Colusa, Placer, Sacramento, Solano, and several other counties.

TABLE 1.—*Plantings of oranges, lemons, and grapefruit in California, by principal counties, January 1, 1924*¹

County	Orchard areas (acres) ²					
	Oranges		Lemons		Grapefruit	
	Bearing	Nonbearing	Bearing	Nonbearing	Bearing	Nonbearing
Butte	1,850	53	46		16	
Sacramento	1,530	25			40	
Other northern	1,375	69	800		20	
Fresno	2,088	424	200	140	5	12
Kern	1,225	75	10		38	
Tulare	35,686	87	2,678	4	1,172	3
Other central	232	24	26	13		
Imperial					450	1,500
Los Angeles	39,825	6,613	11,263	4,277	378	97
Orange	41,226	3,151	9,536	1,485	63	28
Riverside	18,753	588	5,095	180	453	147
San Bernardino	38,759	1,933	5,000	600	1,500	51
San Diego	4,342	45	7,092	341	84	16
Santa Barbara	130	16	1,360	14	8	
Ventura	3,132	1,344	5,611	317	10	
Total	190,153	14,447	48,627	7,377	4,237	1,854

¹ Data furnished by E. E. Kaufman, statistician, California Cooperative Crop-Reporting Service.

² Estimated plantings for 1923 not included are as follows: Oranges, 565 acres; lemons, 335 acres; grapefruit, 1,118 acres.

The citrus plantings as of January 1, 1924, are given by the California Cooperative Crop-Reporting Service as 268,703 acres, with about 24,000,000 trees. The distribution of the orange, lemon, and grapefruit acreage as of January 1, 1924, by counties having over



FIG. 2.—Map showing by black patches and dots the distribution of the citrus producing areas in California on January 1, 1924

1,000 acres is presented in Table 1, and the general distribution in the State is shown geographically in Figure 2. The citrus shipments from California during recent years are shown in Table 2.

The northern and central California districts are located in the interior valleys of the Sacramento and San Joaquin Rivers, respectively, where climatic conditions are rather extreme. The air is

nearly always hot and dry in summer, the days are usually clear and sunny, and the absence of dews and fogs is very marked. The winter rains are generally abundant, especially in the more northern sections.

TABLE 2.—*Citrus fruits shipped from California during the four crop years ended October 31, 1924*

[Data furnished by the California Citrus League. The shipments in 1921-22 were reduced by frost damage that winter]

Season ended October 31—	Shipments (carloads)	
	Oranges and grapefruit	Lemons
1920-21.....	48,350	11,797
1921-22.....	29,573	9,926
1922-23.....	50,966	8,741
1923-24.....	47,635	13,097

In the southern California district there are three areas climatically—the Coachella and Imperial Valleys, marked by even greater extremes of summer heat and dryness than the northern and central districts and with an average annual rainfall of only about 2 inches; the upper Santa Ana River Valley, which is somewhat like the northern and central districts in its dry summers and bright days but with much cooler nights; and the coast section, where the proximity of the Pacific Ocean makes the climate more equable, with cooler summers and warmer winters and where frequent heavy dews and fogs increase the atmospheric humidity.

The climatic extremes which mark the northern and central districts and the Coachella and Imperial Valleys are responsible for the more rapid maturing of the fruit in those sections, which permits marketing it somewhat earlier than in other parts of the southern district. We thus have the anomalous condition of oranges grown in Butte and Glenn Counties which are marketable earlier than those in San Diego County, more than 500 miles farther south.

DEVELOPMENT IN ARIZONA

The citrus industry in Arizona is about 35 years old and is still relatively small in extent. The old trees in the Ingleside grove in the Salt River Valley northeast of Phoenix are the survivors of what was probably the first citrus orchard in Arizona. Here in 1889, W. J. Murphy planted 20 acres of orange and lemon trees from California, together with a number of olive and other fruit trees. Their success resulted in additional plantings in that district, and to-day the commercial citrus development of the State is limited to an area within a radius of a few miles from this first grove, with the addition of a small acreage at Yuma.

The first orchard planting in the Yuma district was made on the mesa just south of Yuma in 1892 by H. W. Blaisdell, 20 acres being planted with oranges and lemons. The success of the venture was such that in 1900 40 acres more were planted to Washington Navel oranges and Marsh grapefruit. In later years the increasing demands of the city of Yuma for water resulted in the neglect of the

orchard, and the lack of available water was the limiting factor for several years in preventing new plantings. In 1916 about 100 acres of Washington Navel oranges and Marsh grapefruit were planted by homesteaders and irrigated by pumping from the valley canal of the United States Reclamation Service. An auxiliary project on the mesa was opened by the Reclamation Service in 1919, but the lack of nursery trees and the strict quarantine against their importation prevented practically all plantings until 1923, after the quarantine had been modified with respect to trees for planting at Yuma.

On July 1, 1924, there were about 1,600 acres of citrus fruits in the Salt River Valley, approximately half being oranges (700 acres of Washington Navel) and the other half grapefruit (about 700 acres of the Marsh variety). All but about 200 acres of this was of bearing age, 75 acres having been planted in 1924, of which 60 acres were Marsh grapefruit.

The citrus production in the Salt River Valley during the 1923-24 season was approximately 200 cars of grapefruit, 130 cars of oranges (80 of the Washington Navel variety), and 5 cars of lemons. Practically 85 per cent of this fruit was handled by a cooperative association.

At Yuma there were on July 1, 1924, about 575 acres of citrus orchards, only 130 acres of which were of bearing age. About one-fourth of the plantings were Washington Navel oranges, and the remainder Marsh grapefruit, with a few lemon trees and other orange varieties. More than 435 acres were planted in 1923 and 1924. This district in the season of 1923-24 produced more than 10,000 field boxes of fruit, which were sold locally and in Los Angeles.

KINDS OF CITRUS FRUITS IN THE SOUTHWEST

The citrus industry of the Southwest was founded upon and has been developed very largely with the common round sweet orange, and at the present time practically four-fifths of the commercial citrus acreage and production are made up of oranges.

Next in importance is the lemon, which comprises nearly all the remaining portion of the commercial acreage and production.

A relatively small acreage is devoted to grapefruit, though the culture of this fruit is being extended more rapidly than any other citrus, especially in the Imperial Valley of California and in Arizona. In these sections oranges seem to be less adapted than grapefruit to the very hot, dry conditions which prevail during the long summers, and new plantings in those localities are composed of continually increasing proportions of the latter fruit. In the Salt River Valley of Arizona the old seedling oranges thrive well, but this fruit is gradually disappearing from commercial shipments in the Southwest largely on account of its normally small size in comparison with that of the standard varieties.

There are a few small orchards of Satsuma and tangerine types of oranges in California, and they usually produce very profitable crops. The culture of both these fruits is being extended slowly, for the market demands for them are somewhat limited. The varieties of the Satsuma type are early ripening and are more resistant than other varieties to low temperatures and other climatic extremes.

Lime trees were planted in a number of places during the early development of the citrus industry, but owing to the extreme tenderness of both the trees and fruits and their frequent injury during periods of low temperature their culture has been largely abandoned. A few trees are still grown in some districts in particularly frost-free locations, to supply local market demands and for experimental study.

The citron of commerce is grown on a very small scale in some districts. An old orchard near Riverside, Calif., produces fair crops under adverse conditions, but the usual lack of profitable demand for the fruit has prevented any growth of the industry.

VARIETIES GROWN IN THE SOUTHWEST

COMMERCIAL VARIETIES

The term "commercial" as here used refers to those varieties which have been proved to produce fruits meeting the market requirements and whose culture has been found to be successful under favorable environmental conditions, so that they have become established on an extensive scale as dependable under normal conditions for the production of profitable crops.

The citrus industry of the Southwest is based upon the culture of only five important varieties—two oranges, two lemons, and one grapefruit. The great advantage of thus limiting commercial production to a few standard and proved varieties has been fully demonstrated.

ORANGE VARIETIES

The early determination of the advantages of the Washington Navel orange, when the fruits of this variety were found to have superior eating qualities, including seedlessness, to possess high color and smooth texture of rinds, giving them an attractive appearance, and to hang upon the trees for a long period in good condition after they became mature, led to the planting of large acreages, which soon resulted in a sufficient production of fruit to furnish the market with regular supplies during the winter and spring months.

After considerable experience with varieties maturing during the time when Washington Navel oranges are not available, the Valencia orange was adopted because it satisfactorily met the market requirements for a complementary variety. With these two varieties oranges are supplied from the Southwest throughout the entire year, the Washington Navel meeting the winter and spring demand and the Valencia meeting the summer and autumn requirements. This condition is largely responsible for the rapid development and commercial success of the citrus industry in the Southwest. The total acreage of Washington Navel and Valencia oranges in the principal producing counties of California is shown in Table 3, compiled by the California Cooperative Crop-Reporting Service.

The Washington Navel orange is believed to have originated at Bahia, Brazil, about 1820, as a bud mutation from the Portuguese variety *Laranja Selecta*. It was introduced to this country in 1870 through the U. S. Department of Agriculture and was distributed

in California and Florida, but has proved to be unadapted to conditions in the latter State.

The Valencia was received from Thomas Rivers, of London, England, in two importations, one direct in 1876 and the other indirectly from Florida at about the same time. The label had been lost from the Florida trees, and the variety was variously known as "Hart's Late," "Hart's Tardiff," and "Hart," but its identity with Valencia was later recognized, and it is now generally given that name.

TABLE 3.—*Orange varieties in the principal producing counties of California on January 1, 1924, excluding the plantings of 1923*

Variety	Orange orchards (acres)	
	Bearing	Nonbearing
Washington Navel.....	92, 306	4, 049
Valencia.....	79, 102	8, 305
Miscellaneous varieties.....	2, 840	10

LEMON VARIETIES

The lemon industry in the Southwest is also based upon the culture of only two varieties, the Eureka and Lisbon, which have been found to meet the market requirements satisfactorily. The Eureka lemon was originated by T. A. Garey, a nurseryman at Los Angeles, in 1877, as a selection of one tree from several that had been grown from seeds of Sicilian lemons which were planted by Doctor Halsey in 1858. It is now the variety most extensively grown in the Southwest.

The Lisbon lemon was introduced into California in a number of importations, the first of which were made as budded trees in 1874 and 1875 from Australia.

These varieties differ in their periods of heaviest production and vary somewhat with changes in climatic conditions. In general the Eureka may be said to be a late spring and summer variety, while the Lisbon bears most heavily in the winter and spring. Because Lisbon trees are somewhat more vigorous and have denser foliage than Eureka trees they are considered by some growers to be more resistant to light frosts and to protect the fruit from winds and sunburn to a greater degree. They are also much more thorny than those of the Eureka variety. Typical fruits of the two varieties differ slightly in shape, but there is so much variation in this respect that it is often almost impossible for an expert to distinguish them. In marketing practice no attempt is made to do so, and they are both handled simply as lemons.

GRAPEFRUIT VARIETIES

The commercial grapefruit industry in the Southwest is considered as dating from the introduction of the Marsh variety from Florida in 1890. Previous to that time a number of small plantings of several varieties had been made, but none of them were found to be commercially successful. Planting varieties other than the Marsh has been practically discontinued in this section during recent years, this variety being accepted as the most desirable from the marketing standpoint.

On account of the climatic conditions which prevail in the Arizona citrus districts and in the San Joaquin, Coachella, and Imperial Valleys of California, grapefruit matures very rapidly in those sections and is distributed locally and in western markets during the late fall and early winter. In other sections where grapefruit is grown it ripens more slowly and does not mature until the following spring. Formerly it was the custom in these districts to pick the fruit during the winter months, when it was immature and not fit to eat. During recent years, largely as the result of investigations by the senior writer, the picking of this fruit has been delayed until May or later, when it is fully ripe and possesses superior eating qualities. Under proper storage conditions, with careful attention to maintaining uniformly high humidity, it has been found practicable to hold ripe grapefruit for considerable periods of time,¹ making it possible to supply the market demands for this fruit during the greater part of the year.

STANDARDIZATION OF VARIETIES

The term "standardization of varieties" is here used to mean the systematic selection of buds for propagation from inherently superior parent trees of the most desirable strains, thus eliminating inferior and diverse strains arising by bud variation. The word "strain" is used to designate a group of individuals of a horticultural variety differing from all other individuals of the variety in one or more constant and recognizable characteristics and capable of perpetuation through vegetative propagation.

It has been found in investigations previously reported² that bud variations are of frequent occurrence in citrus trees and that through their intentional or (as has been more frequently the case) unintentional propagation they give rise to diverse strains, many of which are inferior to the typical or best strains. It has been demonstrated experimentally and proved commercially that by using fruit-bearing budwood with typical fruits attached from heavy and regular bearing parent trees which have been found to be inherently stable it is possible to propagate uniform trees of the best strains which will produce superior crops of fruit.

The effect of this standardization upon the production of citrus varieties is to increase the yield as well as to improve the quality and commercial grade of the product. In the commercial varieties grown in the Southwest the trees of the stable and best strains are normally more productive and more regular than those of the variable and inferior strains. For example, the trees of the Australian strain of the Washington Navel orange variety produce small yields of undesirable fruits in comparison with the trees of the Washington or best strain under the same cultural conditions.

¹ Lon A. Hawkins and J. R. Magness. Some changes in Florida grapefruit in Storage. *In Jour. Agr. Research*, vol. 20, pp. 357-373. 1920.

² A. D. Shamel, L. B. Scott, and C. S. Pomeroy. Citrus-fruit improvement: A study of bud variation in the Washington Navel orange. U. S. Dept. Agr. Bul. 623, 146 pp., illus. 1918.

— Citrus-fruit improvement: A study of bud variation in the Valencia orange. U. S. Dept. Agr. Bul. 624, 120 pp., illus. 1918.

— Citrus-fruit improvement: A study of bud variation in the Marsh grapefruit. U. S. Dept. Agr. Bul. 697, 112 pp., illus. 1918.

— and C. L. Dyer. Citrus-fruit improvement: A study of bud variation in the Eureka lemon. U. S. Dept. Agr. Bul. 813, 88 pp., illus. 1920.

— Citrus-fruit improvement: A study of bud variation in the Lisbon lemon. U. S. Dept. Agr. Bul. 815, 70 pp., illus. 1920.

The trees of the Alternate-Bearing strain of the Marsh grapefruit variety bear full crops only every other year, with an average yield which is usually considerably below that of the trees of the Marsh or best strain. The low production in many citrus orchards has been found to be due almost entirely to the presence of trees of inferior strains.

In established healthy orchards the standardization of the varieties planted can be accomplished through top-working the trees of the off strains with buds taken from superior trees of the best strains. In the case of new citrus orchards this standardization is effected by planting only trees grown from buds carefully selected from superior trees of the best strains.

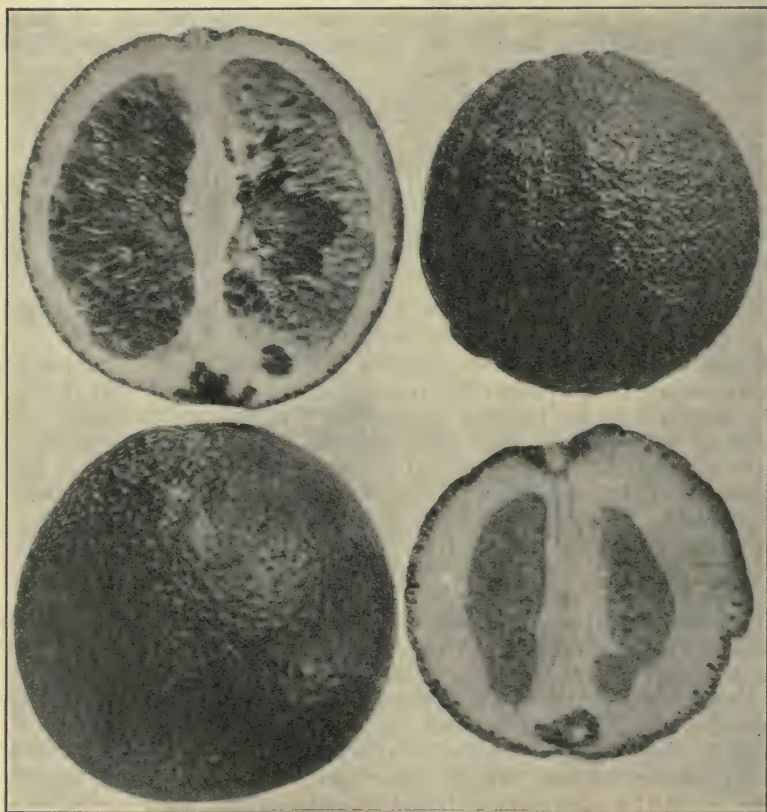


FIG. 3.—Typical fruits of the Washington Navel orange at the left and fruits of the Dry strain produced on a limb sport in the same tree which was grown from a single bud. Propagations from this mutant limb have developed trees bearing similar dry fruits. (Highgrove, Calif., April, 1923)

STRAINS OF THE LEADING VARIETIES

An individual-tree study in several Washington Navel orange orchards in southern California which was begun by the senior writer in 1909 revealed the presence of several diverse strains. Thus far, 13 important strains of this variety have been found, and many

other less marked departures from the Washington strain have been noticed. Descriptions of the important strains of the principal citrus varieties will be found in the publications mentioned in the footnote on page 9. The following are most frequently found in established Washington Navel orchards and are probably the most important ones: Washington, Thomson, Australian, Golden Nugget, Unproductive, Corrugated, and Dry. The Washington is the best of these on account of the productiveness of the trees and the superior commercial and eating qualities of the fruit. The other strains are more or less inferior and are not now being propagated except for experimental purposes. An illustration of one of the least desirable of these strains is shown in Figure 3.

In the Valencia variety 13 important strains arising from bud mutations have been found. Many minor and less frequent varia-

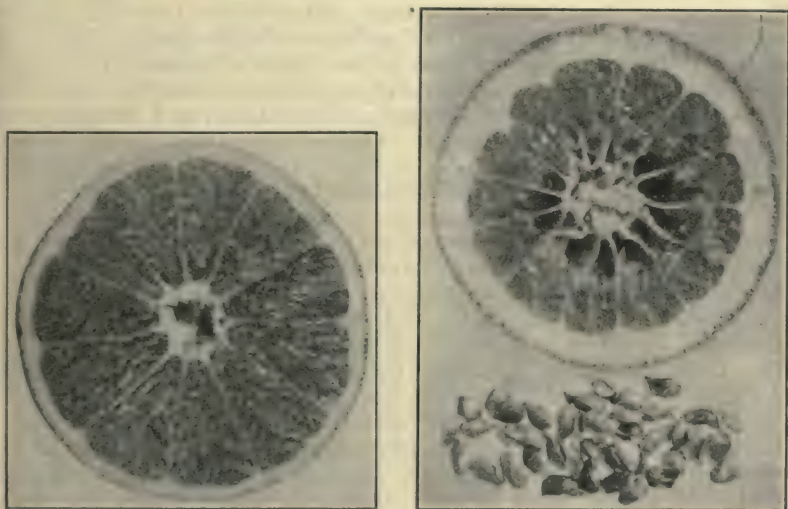


FIG. 4.—Cross sections of typical fruits of the Marsh and Rough-Seedy strains of the Marsh grapefruit, the latter a bud variation from the former. (Highgrove, Calif., July, 1916)

tions have been discovered, but they are apparently of little commercial importance. The following strains are of most frequent occurrence: Valencia, Corrugated, Ribbed, Long, Unproductive, Rough, and Sporting (or Variable). The Valencia strain is the most valuable of these. Its fully mature fruits are of good eating quality, inferior only to the Washington Navel of the oranges of the Southwest. The other strains of the Valencia are inferior for all conditions of culture so far as known. They are of great scientific interest, but of commercial importance only when occurring as mixtures in Valencia orchards.

Among the eight strains of the Eureka lemon which have been classified thus far the most important are the Eureka, Shade-Tree, Dense-Unproductive, Pear-Shape, and Variegated. The Eureka strain is the most productive and valuable, the others being distinctly inferior for commercial lemon growing. The unintentional

propagation of bud variations in the Lisbon variety has given rise to at least six important strains: Lisbon, Open, Dense-Unproductive, Bull, Variegated, and Sporting (or Variable). Of these, the Lisbon is the most important commercially. The trees of this strain seem to be particularly well adapted for growing in regions near the seacoast and are also suited to conditions in some of the interior districts. The other strains are less desirable than the Lisbon and should be eliminated in established orchards through top-working or replanting.

In grapefruit orchards of the Marsh variety seven strains arising from the unintentional propagation of bud mutations have been discovered, of which the following are the most important: Marsh, Alternate-Bearing, Rough-Seedy, Smooth-Seedy, and Unproductive. The trees of the Marsh strain are regularly productive, bearing oblate-shaped fruit with the stem end often slightly sunken. This flattened shape is an important characteristic from the market standpoint, serving to identify the fruits of this strain. The comparatively large number of seeds in the fruits of some of the strains is an important factor in disqualifying them for further propagation. Cross sections of typical fruits of the Marsh and Rough-Seedy strains are shown in Figure 4.

MINOR VARIETIES

Several varieties of oranges of minor commercial importance are still grown to a limited extent, including the Ruby, Maltese Blood (*Malta Blood*), Mediterranean Sweet, St. Michael, and a number of named seedlings. The Ruby and Maltese Blood varieties are so extremely variable that it is difficult under present conditions to make uniform market grades of them. They also bear small, seedy fruits, and their red flesh does not appeal to the general public. The Mediterranean Sweet was formerly a popular variety in some districts, but on account of its irregular production its culture has been largely abandoned. The St. Michael is a fine-flavored orange, but it bears very small fruits with tender rinds which are easily injured in handling, so that most of the trees of this variety have been top-worked during recent years. The Mission seedling was the first orange introduced in the Southwest. Other seedlings adapted to local conditions were introduced from time to time, and a few of them are still grown in some districts. The principal favorable character of the seedlings is their usual regular and heavy bearing even under many extreme climatic conditions, but the normal small size of the fruits is a factor resulting in the gradual top-working or replanting of these orchards.

The Villafranca lemon was very popular in some districts during the early development of the industry. Because the normal yield of this variety is relatively low and it produces its main crop during the most undesirable marketing period, it has been practically eliminated from culture.

The Duncan and Triumph varieties of grapefruit are considered by some growers to be superior to the Marsh, but their high seed content has been largely responsible for their abandonment for commercial culture.

PROPAGATION OF CITRUS TREES

The growing of reliable citrus nursery trees is a highly specialized industry. In the Southwest it is conducted largely by professional nurserymen who, as a rule, confine their work to the propagation of citrus trees alone. A few growers propagate their own trees, selling their surplus to other growers.

Citrus trees are universally propagated in the Southwest by budding on seedling stocks. During the past 10 years fundamental improvements have been made in methods of propagation, among the most striking of which are the use of budwood taken from superior parent trees and the use of carefully selected root stocks. Citrus orchards which have been propagated in this way are made up of trees of uniform size and type and bear heavier crops of more uniformly good fruits than comparative orchards planted with ordinary trees.

The planting of reliable trees or those which are known to be inherently good is a matter of great importance to citrus growers. The term "reliable trees" is here used to mean those which have been propagated from buds taken from superior parent trees on root stocks which have been selected as uniformly desirable for the conditions under which the trees are to be grown. The term "superior parent tree" is used to indicate full-bearing trees which are known to produce regular, heavy, and uniformly desirable crops.

ROOT STOCKS

For all commercial citrus varieties in the Southwest the sour orange has proved to be the best root stock. Adequate supplies of sour-orange seed can be procured from Florida, and a small but increasing supply is available in the Southwest. The seedlings make congenial bud unions, are resistant to gummosis, scaly bark, and other citrus diseases, and are hardy and adapted for growth under the environmental conditions of the Southwest.

Recent investigations in California have demonstrated that seedlings from certain parent sour-orange trees are more uniformly vigorous than those from other trees and have superior habits of growth. It is important, therefore, whenever possible, to select as sources of seed only those trees which have been proved to transmit the desired characteristics to their seedling progenies. Orchard plantings of carefully selected orange seedlings are now being made in southern California in order to provide sources of seed from desirable types of parent trees.

The seeds for root stocks are sown in beds, where they are normally grown for a year. The seedlings are then transplanted or "lined out" in nursery rows about 4 feet apart and spaced about 1 foot apart in the rows, all weak, deformed, or otherwise undesirable ones being discarded. Before replanting the tops and taproots are usually cut back to about two-thirds of their length.

BUD SELECTION

The importance of systematic bud selection in propagating inherently good citrus trees has been demonstrated experimentally and commercially during the past 10 years. In order to make carefully

selected buds readily available to all growers and nurserymen, a bud department was organized as a public service by the supply company of the California Fruit Growers Exchange in cooperation with the United States Department of Agriculture. That office secures and distributes at cost selected budwood from superior parent trees and furnishes information regarding supplies of nursery trees propagated from such buds. From the establishment of that office in May, 1917, to July 1, 1924, it distributed 2,850,000 selected buds to many of the citrus sections of the world. The success of this undertaking, which has been self-supporting from the start, shows that nurserymen and growers appreciate the value of systematic bud selection in improving citrus production. A description of this cooperative work is given in the Yearbook of the United States Department of Agriculture for 1919.³ Improvements in the methods of bud selection are being developed constantly as a result of scientific investigation, but the fundamental principles underlying these methods will be briefly described.

The basis of bud-selection work is the determination of inherently superior parent trees as sources of budwood for propagation. The selection of such trees is based upon individual-tree performance records, intimate tree knowledge, and progeny tests. While records of the quantity, commercial quality, and regularity of production are important considerations, the uniformity in type of fruits, the absence of marked variations, and a knowledge of the characteristics of the various strains gained through wide orchard experience are also of special importance in carrying out this work.

The individual-tree performance records should be made from a large number of trees in full bearing in orchards where the environmental conditions are uniformly good and that are known to produce large crops of fruit of the highest commercial quality. To be of the greatest value these records should cover a period of not less than four years of normal fruit production.

Trees having a production that is otherwise satisfactory but which show variations in fruit or foliage should in no case be selected as sources of budwood for commercial propagation. Experimental tests and orchard experience have shown that citrus trees grown from buds taken from the normal growth of trees which have even a single branch bearing variable crops are likely to produce variable crops of inferior value.

Performance records of progeny trees grown from buds taken from superior parent trees are the best and most reliable indication of the stability of these trees, and they determine those trees that are prepotent in transmitting their desirable characteristics. In California, where extensive progeny tests have been conducted for several years, it is now possible to select superior parent citrus trees on the basis of progeny performance.

The cutting of budwood for propagation from superior parent trees should be done as nearly as possible at the time when the buds are to be used, but if necessary the wood can be stored for several months under proper conditions of temperature and humidity.

Fruit wood only should be cut for budwood, and, if possible, fruit-bearing wood should be selected with typical fruits attached,

³ A. D. Shamel. Cooperative improvement of citrus varieties. U. S. Dept. Agr. Yearbook, 1919, pp. 249-275, illus. 1920.

as shown in Figure 5. This precaution is desirable because the fruits attached to the bud sticks make it possible to avoid branches bearing variable fruits and to be certain that the budwood does bear superior fruits, indicating the type that may be expected from the trees grown from these buds. The immature wood back of the fruits is most desirable for propagation. While such bud sticks are usually smaller than those from older growth or from the more vigorous vegetative branches, commonly called suckers, they give results equally good, if not better. Figure 6 shows a Eureka lemon nursery propagated in this way and illustrates the satisfactory growth and early-fruited characteristics of such trees.

BUDDING

Seedlings are commonly budded in the spring during the period of growth from March to June, inclusive, or at the time of fall growth, which usually comes in September and October, but it can be done at any time when growth is active and the bark slips easily.

Relatively high budding, from 6 to 10 inches above the ground, is now generally preferred, because there is less danger of the bud unions being covered with soil with the subsequent development of adventitious roots or of gummosis or other troubles of the scions after such trees are set in the orchard. Seedlings which have made a satisfactory growth so that they can be budded after one year in the nursery are considered most desirable.

The usual method of budding citrus in the Southwest is by the use of shield buds inserted in inverted T-shaped incisions. The cut bark is then bound in place by wrapping with strips of waxed cloth, which are removed after two or three weeks, when the buds have united with the stocks. When fall budding is practiced the dormant buds are left wrapped until the following spring. At the time the wraps are removed or soon afterwards the stocks are cut off about 6 inches above the bud. A recent test has shown that if the trees are lopped instead of being cut off the new growth is much more rapid and vigorous.

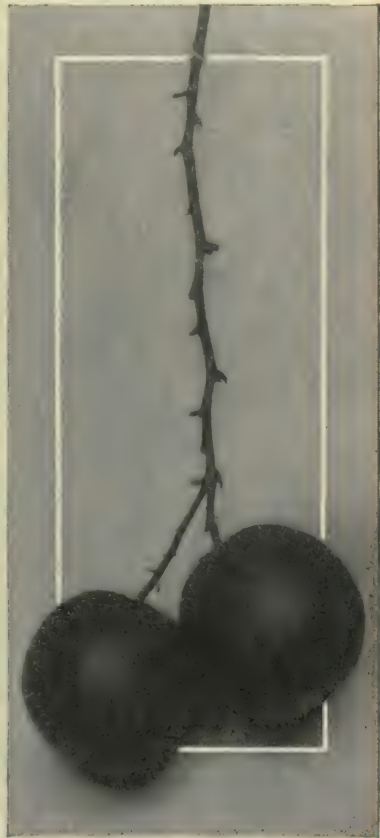


FIG. 5.—Typical fruit-bearing Valencia orange bud stick, showing the type of budwood secured for propagation

GROWING NURSERY TREES

The training of nursery trees includes staking them, heading them at the proper height, and spacing the framework branches. Lath stakes are driven into the ground about 2 inches from the base of the seedlings on the same side as the buds, and the growth from the



FIG. 6.—Nursery trees of the best strain of the Eureka lemon variety two years after budding on sour-orange stock. These young trees blossomed and small fruits developed while still in the nursery row. This is characteristic of the young trees propagated by the use of improved methods

inserted buds is trained to grow straight by being tied every few inches. When the trees have reached a diameter of about half an inch the seedling stubs are cut back with a sloping cut as close to the young tree trunks as possible and the wounds covered with grafting wax.⁴

⁴ A very satisfactory grafting wax is made of equal parts of beeswax and rosin. For inarching 2 parts of beeswax to 1 of rosin are used. Others use beeswax alone for all purposes. A satisfactory formula which is less expensive is as follows: Rosin, 4 pounds; beeswax, 1 pound; tallow, 1 pound (or linseed oil, 1 pint). Melt together in a kettle. In hot weather use more rosin. Apply warm with a brush.

When the trees are about 3 feet high they are cut back to 28 to 30 inches. There is an increasing partiality among growers for high-headed trees, some preferring to have them 36 inches high. A number of lateral branches will then develop along the upper part of the trees, from which three to six spirally spaced ones are selected to form the framework of the tree, all other growth being carefully removed.

At the time of transplanting, the main branches are cut back to 8 or 10 inches in length, to check excessive transpiration during the moving operations and to compensate for the roots cut off in digging the trees. There is an increasing preference for trees which were in the nursery for a year as seedlings and which have made a sufficient growth to be transplanted one year after budding.

DIGGING NURSERY TREES

Digging nursery trees for transplanting is done during either spring or fall, the spring usually being considered best for this work. Balling has been the general practice in nursery transplanting, but the bare-root system is now used to a considerable extent. The chief disadvantages of balling are the heavy weight of such trees and the additional expense of digging and moving them.

If the trees are not to be planted at once they should be moved to a lath house or other shelter where they can be kept moist and protected from the sun and wind. If they are to remain unplanted for a considerable time they should be set on a layer of dampened sawdust with additional sawdust thrown around and between them and sprinkled from time to time.

The bare-root method of transplanting nursery trees is particularly advantageous when they are to be moved only a short distance and when all operations have the careful supervision of experienced men. The roots must be kept covered with wet sacks or other moist material, and it is often desirable to pack the trees in crates with the roots covered with dampened moss.

LOCATION OF THE ORCHARD

In the selection of a desirable site for a citrus orchard care should be taken to choose a location relatively free from frosts and heavy winds, with an adequate supply of good water and preferably with a loam type of soil having good underdrainage and free from alkali dangers.

Liability to frost damage is one of the most important factors in the consideration of an orchard site. The distribution of frosts in the past few years has indicated that no general locality can properly be considered entirely free from this danger, but in most sections there are more or less restricted areas which on account of various local conditions of relative elevation, natural protection, or some other favorable circumstance are least liable to be injured during periods of low temperatures. In growing lemons, the relatively frost-free sections are especially desirable, as both the trees and fruits are more tender than oranges.

Heavy and extremely dry northerly winds are rather common in some regions of the Southwest during certain seasons of the year, and experience has shown that such areas should not be planted to citrus fruits.

DEVELOPMENT OF THE ORCHARD

PREPARATION OF LAND FOR PLANTING

The method of preparing the land for planting depends to a large extent upon its nature and previous history. This discussion is confined to the preparation of virgin land or land upon which legume, grain, or similar crops have been grown, but where orchards have not previously been planted.

Virgin or rich soils usually do not need any particular treatment after they have been cleared. Where legume crops have been grown for some time the soil is normally in good condition, but if the land has been cropped with barley, wheat, or other grains it is frequently advisable to grow a legume or other green-manure crop and plow it under to improve the soil tilth and fertility.

Formerly it was the common practice to level uneven land before planting by scraping off the higher spots and filling the lower areas, so that the trees could be set in straight rows and properly irrigated, but during recent years such scraping is usually avoided by contouring uneven land, that is, running the tree rows with the contour levels. Naturally some leveling may be necessary in laying out contour rows to provide for the proper flow of irrigation water, but with this method of planting such work is reduced to the minimum.

To provide the most desirable conditions of soil tilth for the young trees and cover crops the area should be plowed and cultivated before the trees are planted. If they are to be set in the spring, as is usual, rather deep plowing after the winter rains is advisable, followed by thorough cultivation. A legume cover crop should be planted, preferably after the trees have been set, to further improve the soil conditions.

In shallow soils or those having a heavy subsoil it is frequently thought advisable to supplement the plowing by subsoiling or by blasting in the holes where the trees are to be set. The desirability of these practices depends upon the local soil and especially the subsoil conditions, oftentimes varying in different parts of the same orchard.

The term "ridging" is used to mean the building up of low ridges upon which the young trees are to be planted. The desirability of this practice depends upon local soil and related conditions, and its advisability should be determined by the experience of growers having similar orchard conditions.

In addition to other fertilization it is usually desirable to bury liberal quantities of well-rotted stable manure or other forms of organic fertilizers in or near the holes where the trees are to be planted. These should be well mixed with the soil or placed below the roots of the trees to prevent injury to them from the heating or other action of the manures.

The irrigation system should be installed before planting the trees, if possible, as it is important that they be watered as soon as they are set.

PLANTING THE TREES

Spring or early-summer planting is generally preferred for citrus trees in the Southwest, but this work may be done during the greater part of the year. Spring-planted trees usually continue growth with only a slight check, and it is less expensive to protect the young trees from possible frost damage during the winter in the nursery than in the orchard.

Planting plans vary somewhat, but the square system is the one in general use, because it permits orchard operations to be carried on most conveniently. Orange and grapefruit trees are usually spaced in rows from 24 to 26 feet apart, with the trees from 20 to 22 feet apart in the rows. This provides for 90 to 76 trees per acre. With lemons the rows are commonly spaced from 22 to 26 feet apart and the trees from 18 to 20 feet apart in the rows, which provides for 110 to 84 trees per acre.

On uneven orchard sites where contouring is necessary it is sometimes found advisable to build terraces to prevent soil washing during rainy seasons. The expense of building and maintaining terraces and of cultivating on them is relatively high, and this fact should be considered before making such plantings.

After the orchard site has been surveyed stakes should be set marking the spots where the trees are to be planted. A convenient method for locating the trees accurately includes the use of a planting board about 4 feet long with a notch at the center and one at each end. The center notch is placed over the marking stake, and pegs are then driven into the ground at the notches in the ends of the board. The board and marking stake are then removed, leaving the end pegs as guides for digging the hole and setting the tree.

The holes should be dug about 3 feet in diameter and 2 feet deep, keeping the topsoil separate from that below and loosening the soil in the bottom of the hole to the depth of the shovel. Sufficient topsoil should then be thrown into the hole so that the bud union of the tree will ultimately stand as far above the ground after planting as it did in the nursery, allowing for the settling of the soil. The planting board is placed over the hole with the pegs in the end notches and the tree trunk in the center notch, and the hole is refilled, using the remainder of the topsoil around the roots of the tree. If balled trees are planted, the cord should be cut and the corners of the sacking spread out and covered with the last few shovelfuls of earth.



FIG. 7.—A recently planted Valencia orange tree, showing the heading back of the framework branches and the trunk protected from sunburn with a newspaper wrapper. (Santa Paula, Calif., May, 1922.)

Planting should begin at the upper ends of the rows, and water should be immediately applied in furrows encircling the trees. The tree trunks should be protected from sunburn and other injuries by wrapping them with newspapers, as shown in Figure 7, or by other protectors.

FERTILIZATION

The improvement of soils through systematic fertilization has received increasing attention during recent years, and at the present time this problem is one of great importance and interest to citrus growers. It is now believed that the chief value of fertilizers for citrus soils in the Southwest lies in their nitrogen and organic content.

The methods of soil improvement in common use include (1) the use of organic manures, (2) the application of commercial fertilizers furnishing organic or inorganic supplies of nitrogen, (3) the growing of cover crops in the orchards, (4) the mulching or covering of orchard soils with organic materials, and (5) resurfacing orchard areas with fresh soil.

On account of soil variability in different orchards, often in the same orchard, soil improvement becomes an individual orchard problem, and no definite rules can be given without considering the nature of the local soil and its response to fertilizer treatments, but certain principles will be briefly discussed which seem to apply to orchard conditions in the Southwest as a whole. Established methods of fertilizer application should be followed consistently until some other method has been proved to be more successful under local conditions.

MANURES

The principal kinds of manures adapted for use in citrus orchards include stable manure, alfalfa hay, bean straw, and guano.

The term "stable manure" is here used to include the manures of horses, cows, sheep, goats, and poultry or other domestic animals. The composition and value of these manures vary with many conditions, including the kind and age of the animals, their feed, and particularly the conditions under which the manures are collected, handled, or stored.

In addition to knowledge of the chemical composition of manures it is important to know that they are free from noxious weed seeds or other injurious substances and from excessive quantities of shavings, soil, water, or other adulterants which add to their weight but not to their value. Ordinarily, good horse manure contains about 0.5 per cent and cow manure 0.75 to 1 per cent nitrogen. The only safe way to buy manures is on the basis of their composition as revealed by careful chemical and physical analyses, the cost of which is fully justified as a legitimate item of fertilizer expense.

Many successful citrus orchardists apply coarse organic manures during the fall or early winter, so that they will have become partially or wholly decomposed before active growth begins in the spring. Others apply the manure in the late winter or early spring, frequently at the time of spring plowing after the winter rainy period has passed.

On account of the limited supplies of stable manure and the greatly increased use of it in citrus orchards during recent years, its cost has risen rapidly, until it has become necessary to look for other sources of organic fertilizers. As a result of this condition alfalfa hay, bean straw, and guano have come into more general use. While these materials are more uniform in composition than stable manure, it is very desirable and a common practice to buy them on the basis of their analyses for nitrogen and organic matter.

Alfalfa hay contains about 2 per cent nitrogen and has been so extensively used in fertilization in recent years as to cause a considerable rise in its price. The poorer or damaged grades are satisfactory for this purpose and are used when they can be obtained. Both the baled and loose hays are sometimes chopped or sawed, in order to facilitate their distribution in the orchard, which is often done with modified manure spreaders.

Bean straw was at one time used extensively in citrus orchards, but the bean growers now apply it so generally to their own lands that the commercial supply has become very limited.

Guano is considered of great value for citrus soils, but its use is restricted at the present time by its limited availability.

The quantity of manure to be used for most economical results depends upon a number of variable conditions. For citrus trees in full bearing an application of manure containing nitrogen at the rate of about $1\frac{1}{2}$ to 2 pounds per tree each year is generally considered adequate in most southwestern orchards, when used in connection with other nitrogenous fertilizers supplying a total of from 3 to 4 pounds of nitrogen per tree.

The broadcast and the furrow methods are commonly used for applying manure.

Broadcasting manure.—Until recent years manures have ordinarily been scattered broadcast and plowed under or mixed with the surface soil by disks or cultivators. An apparent advantage of this method is that the fertilizer is distributed over all the spaces between the trees, and soils in poor physical condition as a result of deficient organic matter are often improved in tilth by this treatment. An objection to this method is that in many instances the broadcasted fertilizers are allowed to remain exposed on the surface of the soil until much of their value has been lost, but this loss can be largely prevented if the freshly distributed manures are promptly plowed or disked into the soil.

Furrow-manure method.—A recent and more economical method of applying organic fertilizers, called the furrow-manure method, which was introduced and developed by the senior writer, has now come into general use in citrus and other orchards of the Southwest. This method provides for the distribution of manures or other fertilizers in furrows from 8 to 14 inches deep alongside the trees. Plows of the middle-burster type are generally used in making the furrows, as shown in Figure 8. The furrows for the first season may be run along both sides of the trees near the drip of the branches in the same direction as the flow of the irrigation water. They may be similarly located the second season, but at right angles to those of the first year if the orchard planting is such as to permit cross plowing. The third year the furrows may

be made parallel to those of the first year but nearer the middles of the tree rows, and similarly placed the fourth year parallel to those of the second year. The arrangement of the furrows for later applications will depend upon circumstances, but in some cases growers have successfully repeated this plan of the first four years.

The furrows made during any one day should be filled and covered the same day or as soon thereafter as practicable. For young trees it is generally considered necessary to distribute the manures only alongside the trees, but with large trees it is desirable to fill the furrows for their entire length. The covering of the furrows is usually done by a plow run on each side of the filled furrows, so as



FIG. 8.—A home-rigged plow of the middle-burster type making a deep furrow for the application of manure. Note the lumps of hard plow sole which were broken up by the plow. (Corona, Calif., September, 1922)

to throw the soil over the manure. The furrows left by this operation may be used for subsequent irrigations if they are in the direction of the irrigation flow.

The furrow-manure method seems best adapted for use in the fall, winter, or early spring. It is often used for the distribution of organic fertilizers just before the cover-crop seed is sown in the fall or at the time of spring plowing, when the cover crops are turned under.

The desirable quantity of manure to be applied in this way depends upon local conditions, but with full-bearing trees an annual application of 5 to 10 cubic feet per tree of good stable manure or its equivalent in other organic fertilizers has given excellent results. As a rule the manure distributed in furrows has given much

better results in improved tree conditions than a larger quantity broadcasted in the ordinary way.

These deep furrows break up compact soils and plow soles, and the decomposing fertilizers markedly improve the physical condition of the feeding-root zone in the soil. The bunched manure tends to increase the water-holding capacity of the soil in the feeding-root area and to prevent the development of the impenetrable plow-sole condition directly below the zone of cultivation. Where cover crops are not grown it may occasionally be advisable to distribute organic fertilizers broadcast, in order to improve the physical condition of the soil throughout the orchard.

COMMERCIAL FERTILIZERS

Commercial fertilizers are here considered as concentrated organic or inorganic plant foods. No attempt will be made to discuss this subject other than to call attention to fertilizers which are commonly thought to be important in promoting citrus tree and fruit development and to others which are believed to be injurious.

Commercial sulphate of ammonia usually contains about 20 per cent nitrogen in a readily available form. The method of application which has given the best results is to distribute it three times during the spring months in the irrigation furrows near the drip of the branches, using from 1 to 3 pounds per tree each time, depending upon the size of the trees. The first application can be made just before the blooming period, the second about a month later, and the third about 30 days after the second. These applications are thought to prevent excessive dropping of the fruits, but the repeated use of large quantities of sulphate of ammonia on certain heavy soils is believed to be injurious.

Dried blood is one of the richest organic nitrogenous fertilizing materials and decomposes rapidly in the soil. The so-called red dried blood contains from 13 to 14 per cent nitrogen and the black grade from 6 to 12 per cent. Both grades contain considerable phosphoric acid, frequently as high as 4 per cent. Ordinarily, an annual application of 10 to 15 pounds per tree is considered adequate for full-bearing citrus trees, and it is usually applied at the time of the late-winter or early-spring plowing, so that it will be turned below the zone of subsequent cultivations. If used at other times care should be taken to apply it so deep that it will not be disturbed during cultivation. Where the furrow-manure system is used dried blood is often applied in the bottom of the furrows.

Cottonseed meal is a valuable nitrogenous fertilizer, ranking with blood in the availability of its nitrogen. When properly prepared and free from hulls it contains about 6 per cent nitrogen. When fed to animals the manure resulting therefrom is particularly valuable for the highly mineralized soils common in many of the citrus orchards of the Southwest. It should be applied in a similar manner and during the same season as dried blood.

Tankage is a highly nitrogenous product, consisting largely of animal wastes from abattoirs, and is likely to be variable in composition. Two distinct kinds are marketed—high-grade tankage, ranging from 9 to 12 per cent nitrogen with a little phosphoric acid, and low-grade tankage, containing from 4 to 9 per cent nitrogen and

3 to 12 per cent phosphoric acid. This product is applied in varying quantities, depending on its composition and the age of the trees, frequently from 10 to 15 pounds per tree being used. It is distributed and incorporated in the soil at the same time and in a manner similar to dried blood.

Garbage tankage as distinguished from other tankage consists of hotel and household garbage treated for use as a fertilizer. It has been reported that in some instance such tankage has contained table salt or other injurious substances, but modern methods of treating the garbage have largely removed the difficulties connected with its use.

Commercial nitrate of soda contains about 15 or 16 per cent nitrogen. While it is one of the most economical sources of nitrogen for fertilizer purposes, its use in many citrus orchards of the Southwest has been largely discontinued during recent years on account of the apparently injurious effect of its sodium element, which in certain soils is said to result in a mottled-leaf condition.

Calcium nitrate has recently come into quite common use as a commercial form of nitrogenous fertilizer. Usually it contains from 13 to 18 per cent nitrogen. From 10 to 15 pounds per tree, frequently applied in fractional quantities at three separate distributions during the spring months, is ordinarily thought to be adequate for full-bearing trees.

Dried or ground fish varies in composition according to its source. If composed of the offal from packing or canning plants it varies so widely that analyses of each lot are needed to determine its fertilizing value. If derived from pomace resulting from the extraction of the oil of menhaden it generally contains from 7 to 8 per cent nitrogen and from 6 to 8 per cent phosphoric acid. About 25 pounds per tree turned under at the time of winter plowing or applied in manure furrows is considered adequate when used with manure or other similar organic materials.

Bone meal has a phosphoric acid content of 22 to 26 per cent, with from 2 to 3 per cent of nitrogen. It is a valuable source of phosphoric acid where that element is needed for orchard fertilization.

Lime or calcium oxide is usually produced by burning limestone. On acid soils and with some other unfavorable soil conditions its use is advisable, but ordinarily southwestern citrus soils are believed to contain sufficient lime.

Experience seems to indicate that satisfactory results are obtained by the application of fertilizers, partly organic and partly inorganic, supplying nitrogen at the rate of about 300 pounds per acre for trees in full bearing. The organic fertilizers in the form of manures should be applied in the fall or winter and the inorganic fertilizers in two or three distributions in the spring. Peculiar conditions of soil may modify this recommendation both as to quantities and kinds of fertilizers, but the large number of successful orchardists following this general practice warrants its acceptance as fundamentally correct.

COVER CROPS

Cover crops are divided into the two general classes of winter and summer crops. The purposes of the winter crop are to protect

the soil from washing or leaching, increase its fertility, improve its physical character, and supply other beneficial soil influences. Some growers believe that certain disadvantages, such as the lowering of the atmospheric temperature on cold nights and the competition of the cover-crop plants with the trees for water and plant food, outweigh the advantages claimed for the cover crop, but recent studies indicate that during cold weather there is little difference in the minimum temperatures in orchards, with and without cover crops and that when turned under in the late winter or early spring no injurious effects from competition occur.

The most successful legumes for winter cover crops in the Southwest are purple vetch (*Vicia atropurpurea*) and yellow sweet clover (*Melilotus indica*). Purple vetch is now believed to be the most valuable plant for winter growth in citrus orchards, and adequate supplies of its seed are available. This seed is usually sown at the rate of about a bushel per acre when the land is prepared for the August or September irrigation. After germination the plants grow rapidly even during cool weather, so that a large tonnage is produced by the time the late-winter or early-spring plowing is done. Melilotus seed is sown in the same manner as purple vetch, but only about 20 pounds per acre is used.

The supply of irrigation water is generally the limiting factor in growing summer cover crops in citrus orchards. Where water is abundant and other conditions are favorable, it is believed that such crops not only add to the soil fertility but that they also tend to prevent considerable loss of young fruits by the so-called "June drop" through improving atmospheric conditions in the orchards. Of these crops several varieties of cowpeas (*Vigna sinensis*), including the Whippoorwill, are the most commonly used, but alfalfa (*Medicago sativa*), broad beans (*Vicia faba*), Lima beans (*Phaseolus lunatus*), and other legumes are grown for this purpose.

INTERCROPPING

In certain sections, particularly near the coast, the growing of Lima beans and other vegetables between the tree rows in young orchards is successfully practiced. The conditions under which this plan succeeds include a rich soil, abundant water supply, and relatively high atmospheric humidity. In interior sections with higher summer temperatures, comparatively low relative humidity, and a limited water supply intercropping has generally been found undesirable.

MULCHING

The term "mulching" is here used to define the use of hay, straw, or other organic materials for covering orchard soils. There are at least two methods of applying organic mulches: (1) By broadcasting over the soils, and (2) by piling in shallow basins under or around the trees. With the broadcasting method irrigation is carried on as usual in furrows under the mulch, while in the second method the irrigation system is arranged so as to flood the basins. This practice has generally proved impracticable in citrus orchards except under certain peculiar conditions, because rodents of various

kinds are likely to nest in the mulches and seriously injure the bark or roots of the trees, and the costs of maintaining the basins and mulches are usually very high.

RESURFACING

The resurfacing or mulching of shallow orchard soils with fresh soil has proved profitable in a number of instances. Recent experience has shown that in orchard areas where the original surface soil was scraped off in leveling the land or where the top-soil has been washed away resurfacing has given very beneficial results. An important factor in this work is a convenient source of fresh soil, so that the hauling cost will not be excessive. Down-hill hauls and mechanical loading and dumping devices reduce costs, and the work may be done when regular orchard activities are slack.

The fresh soil should be applied to a depth of about 4 to 6 inches, care being taken to keep it from the tree trunks. Fertilization should not be discontinued in the treated areas, although its need may be lessened for a year or so. The advisability of resurfacing should be determined by treating a small area before the practice is adopted throughout an orchard.

CULTIVATION

The common method of cultivation is to plow the ground before or as soon after the winter rains as possible, sometimes as early as January but more frequently during February or March, and to cultivate the soil after each irrigation until the fall cover crop is sown. Moldboard or disk plows are used for the early plowing and stiff-shank, spring-tooth, disk, or other harrows and drags are used for later cultivations. If weeds develop under the trees it may be necessary to remove them with hoes.

Orchards should be cultivated as soon as practicable after irrigation, for without such cultivations many soils, particularly those of a heavy nature, become baked and cracked, resulting in the loss of moisture and the development of other unsatisfactory soil conditions. After the irrigation furrows become dry enough to prevent puddling, it is ordinarily a good plan to use a smoothing harrow or drag to scratch the surface lightly and break up any crust that may be forming, a second cultivation following in a few days to stir the soil thoroughly.

In many irrigated citrus soils in the Southwest a hard and impervious condition known as "plow sole" develops a few inches below the surface during the summer months to such an extent as seriously to hinder or prevent the free circulation of air and the penetration of irrigation water. This condition is believed to result from the practice of plowing or cultivating at about the same depth continuously. Tests made with a soil auger, preferably shortly before irrigations, will indicate the development of the plow sole. As a result of this condition the roots receive insufficient moisture, causing wilting of the foliage, particularly during periods of low atmospheric humidity, and checking both fruit and vegetative growth, while in extreme instances the trees become partially defoliated and much of the fruit drops.

Generally the plow sole can be broken up with special stiff-shanked cultivators or by running a subsoil plow midway between the rows, so as to do minimum injury to the tree roots. Lumps of hard plow sole broken up by a furrow manure plow can be seen in Figure 8.

IRRIGATION

The citrus tree, being an evergreen, uses soil moisture constantly but in varying quantities during different seasons. In most instances the irrigation supply is from streams or wells controlled by water companies or associations of growers, but in some cases it is

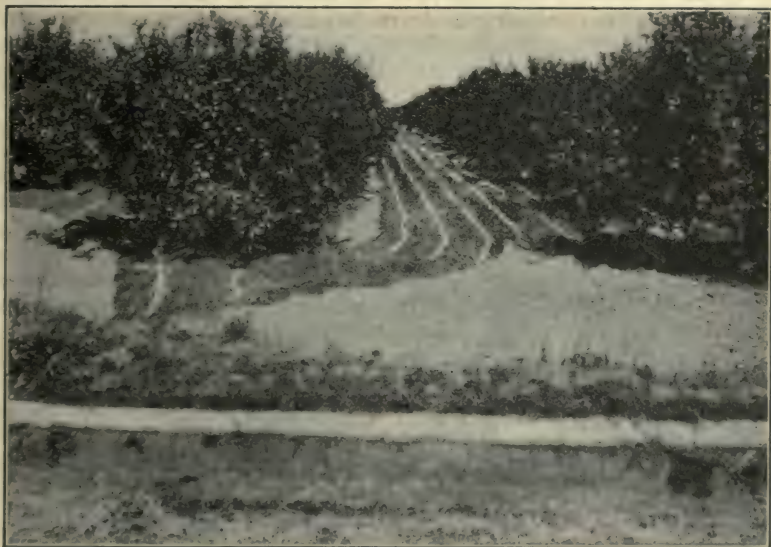


FIG. 9.—Straight irrigation furrows supplied with water from an open concrete ditch. (Corona, Calif., August, 1922)

developed from privately owned wells or other sources. The purity of all irrigation water should be carefully determined, especially with regard to the presence of injurious salts or alkalis.

The Southwest is a semiarid region, where the annual rainfall is unequal to the needs of citrus trees and is largely confined to the winter months. Additional water must be supplied during the period of little or no rain. Bearing citrus trees in the Southwest require from 35 to 45 acre-inches annually, depending largely upon the age of the trees and the soil and climatic conditions. As the average annual rainfall in most citrus districts is only from 10 to 25 inches, irrigation must be depended upon to supply the remainder.

If winter or summer cover crops are grown, additional water must be supplied in order to meet their requirements without interfering with the moisture supply of the trees. Where wells are depended upon they should be sufficiently deep to insure a supply during consecutive seasons of possible drought.

Irrigation is ordinarily begun from four to eight weeks after the last heavy winter rain and is repeated about every 30 or 40 days with an application of 3 to 5 acre-inches each time until the rains begin again. In some districts citrus trees require irrigating nearly every month in the year, but in most sections from five to nine irrigations are usually sufficient. Recent experience indicates that on some soils more frequent irrigations are desirable, with smaller quantities of water at each application. It has been determined that it is important to maintain optimum moisture conditions in the first 3 or 4 feet of soil, the feeding roots being largely distributed in the first 2½ feet. An excess of water which penetrates below this depth is usually lost and is of no benefit to the trees or the soil except when it is necessary to drive down injurious salts.

During recent years many of the leading growers have adopted the practice of basing the length of the intervals between irrigations and the quantity of water applied at each irrigation upon a series of systematic soil-moisture determinations throughout their orchards. In these tests the wilting coefficient and the water-absorbing power of the soil are determined, and the system of irrigation is planned so as to maintain the moisture condition in the feeding-root zone as near the optimum as practicable. It is believed that a reorganization of the present irrigation methods based upon the requirements of the trees and the soil-moisture conditions in individual orchards is of fundamental importance in maintaining and developing the citrus industry in the Southwest.

Irrigation water was first conveyed in open dirt ditches and canals and by wooden viaducts. These were gradually supplanted by open concrete-lined canals, which are now being replaced by underground steel or concrete pipe lines, but all these methods are still in use. Concrete pipes are considered most economical and are most commonly used, but steel pipe is frequently used for main lines where the pressure exceeds 10 or 15 pounds per square foot.

After the water reaches the orchard it is taken from the main pipe line and distributed either through open concrete flumes, as shown in Figure 9, or by underground pipes to each tree row. Open flumes are provided with small gates through which the water flows directly to the irrigation furrows. Such flumes are objectionable, because they obstruct the movement of orchard tools, are easily clogged with rubbish, and are subject to frequent breakage. Underground pipe lines are laid deep enough to be out of the way of cultivation implements and are provided with concrete hydrants or standpipes for each row of trees, as shown in Figure 10. These hydrants are usually fitted with valves for regulating the flow of water into them and have adjustable gates through which the water flows to the furrows.

From four to eight furrows are ordinarily made between each two rows of trees with a special furrowing implement, and additional furrows are often zigzagged in order to wet the soil between the trees in the rows. The proper length of run of irrigation water depends upon the type of soil and the slope of the land. Runs of 300 to 400 feet are preferable in most soils, but in heavier ones or those having a heavy clay subsoil runs of 600 to 800 feet are sometimes used satisfactorily.

The water should be applied for 24 to 72 hours, a 48-hour application being generally used. The flow should be so regulated that the water reaches the bottom of the furrows in about one-fourth the time of the total application. Further details concerning irrigation practices in citrus orchards can be found in Farmers' Bulletin No. 882, *Irrigation of Orchards*.⁵

The cost of irrigation water varies from a minimum of about \$1.50 per acre annually on some of the original Spanish land grants to as much as \$50 to \$75 where the water is expensive and considerable pumping is necessary. The expense for water and irrigation labor commonly runs from \$15 to \$25 per acre for oranges and \$30 to \$40 for lemons.



FIG. 10. Irrigation hydrant from buried pipe line showing gates through which water is admitted to the furrows. (San Dimas, Calif., August, 1922)

PRUNING

The training of citrus trees begins in the nursery when the young trees are headed. Other pruning of young trees of productive strains should be avoided, aside from the training of the main limbs and the removal of crossed branches or other objectionable growth. It has been demonstrated that the early fruiting of young citrus trees does not interfere with their later growth or development.

The pruning of older trees includes the training of suitable growth for framework limbs and the removal of suckers or other objectionable branches. Horizontal or drooping growth and fruit spurs should be allowed to set fruits undisturbed. The cutting back of such branches stimulates continued vegetative growth and delays fruit production.

⁵Fortier, S. *Irrigation of orchards*. U. S. Dept. Agr., Farmers' Bul. 882, 40 pp., illus. 1917.

Two methods of training framework branches are commonly practiced, one resulting in what are termed vase-shaped and the other in so-called bowl-shaped trees. By the vase-shape method the main upright limbs are allowed to grow undisturbed except for essential thinning of interfering growths, resulting in rather tall, upright-growing trees with more than ordinary strength of framework.

By the bowl-shaped method the large inside branches are cut out and the main framework limbs occasionally cut back. These limbs develop new branches, two or more of the outside ones being saved and the remaining upright-growing ones being removed, care being taken not to disturb the horizontal or drooping branches. The new framework branches in turn are cut back when they reach 3 or 4 feet in length and the new growths trained as before. In this way a spreading and open, or bowl-shaped, tree top is secured, resulting in rather low, open, and spreading trees. Such trees are more conveniently picked and more easily fumigated and sprayed than the taller vase-shaped ones. The best method of pruning the individual tree will depend upon the variety, environmental conditions, and local experience.

The best season for pruning is usually during the late winter and in the spring. Ordinarily the spring months are most suitable for this work, but it can be carried on for a longer period if necessary. Care should be taken to avoid pruning during the late fall or early winter, when new growth following the pruning is likely to be injured by dry winds or low temperatures. Pruning during or just following the blooming period is thought to reduce the crop of the succeeding season. Large pruning cuts should be painted over with grafting wax, asphaltum, or some similar material immediately after pruning.

Severe pruning of healthy citrus trees of the most desirable strains is unnecessary and usually causes a reduction of the crop about in proportion to the severity of the pruning. In an orchard test conducted by the writers, severely and moderately pruned Washington Navel orange trees produced less fruit, with no improvement of commercial quality, during a period of eight years following the pruning, as compared with unpruned trees in the same plat.

Citrus trees should be inspected at least once each year and given such pruning as may be necessary. Each tree presents an individual problem and should be treated accordingly. As a rule, there is greater danger of loss and damage by overpruning normal citrus trees than from a lack of pruning. Details regarding methods of pruning citrus trees are given in *Farmers' Bulletin No. 1333, Pruning Citrus Trees in the Southwest*.⁶

CARE OF INDIVIDUAL TREES

The care of individual trees includes renewal, top-working, re-planting, transplanting, treating diseased, girdled, broken, or otherwise injured trees, and similar activities. On most of the larger citrus orchards in the Southwest there is now at least one man whose duty it is to attend to work of this nature, and experience has proved

⁶ A. D. Shamel, C. S. Pomeroy, and R. E. Caryl. Pruning citrus trees in the Southwest. U. S. Dept. Agr., *Farmers' Bul.* 1333, 31 pp., illus. 1923.

this plan to be profitable. In small orchards the grower can usually do this work himself.

Systematic individual-tree performance-record work or tree-estimate data are essential to the intelligent care of the tree in many cases. Individual-tree numbers make it possible to record the location of trees needing attention, and the performance-record data enable the grower to determine accurately those trees which should be top-worked or replanted.

SECURING INDIVIDUAL-TREE PERFORMANCE RECORDS

The objects of individual-tree performance-record work include: (1) Securing definite information on the results of variations in soil or cultural practices and care of the individual tree as the basis for the introduction and use of improved methods, (2) locating superior parent trees as sources of budwood for propagation, (3) determining inferior trees for top-working or replanting, and (4) comparing the behavior of different varieties, strains, or progenies.

Individual-tree performance data normally include records of the yield and the commercial quality of the fruit of each tree with descriptions of the foliage and fruit characteristics. For commercial purposes these data need to show only the number of boxes of fruit that are produced by each tree, together with notes on any unusual condition of fruits or growth, such as the occurrence of striking bud variations, disease or malnutrition troubles, and pest or other injuries.

In the case of young orchards it is often desirable to start individual-tree records as soon as the trees begin to bear, in order that undesirable trees may be replaced with a minimum loss. The records should be continued for several years, as, for example, four or more normal years. While records for two normal seasons supply valuable information, the value of these data increases rapidly with additional records, and a 4-year period is considered to be the minimum from which reliable conclusions can be drawn.

The important considerations involved in carrying on individual-tree performance-record work are the use of an individual-tree numbering system, the organization of the picking work so that each tree is picked separately, and the adoption of a systematic plan of recording the individual-tree yields and other observations.

In the extensive work now under way in California it has been found advisable to give each tree a number of three parts as, for example, 2-13-8, meaning block 2, row 13, and tree 8 in the row, always basing this arrangement on some fixed landmark, such as the irrigation heads. In small plantings it is usually unnecessary to use a block number. This tree number fixes the identity of each tree for observations over an extended period, and by it any tree may be found without difficulty. The figures are usually put on the lower part of the tree trunk with white paint in a vertical column, and they should always be placed in the same relative position.

The picking boxes should be distributed so that the crop of each tree is kept together until its record is ascertained. In some cases the estimated number of boxes is distributed to each tree, as shown in Figure 11, while in other instances the boxes are set in rows in such a way that the crop of each tree can be identified and studied.

The number of boxes of fruit produced by each tree is usually recorded by the picking foreman on blank forms adapted for this work. Further directions for securing and using individual-tree performance records are given in Farmers' Bulletin No. 794, *Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records*.⁷

INDIVIDUAL-TREE ESTIMATE DATA

Individual-tree estimate records are often useful in carrying on tree work where performance records are not available. The tree-estimate data usually include an estimate of the crop borne by the



FIG. 11.—Picking Washington Navel oranges, with field boxes distributed to each tree for the purpose of securing records of the yields of the individual trees. In many cases ladders with three legs are used, so as to avoid injuries to the trees or fruit from the pressure of the ladders. (Highgrove, Calif., April, 1915)

individual tree, with notes on the commercial quality of the fruit and the foliage characteristics. With the aid of suitable note forms and tree numbers these records can be made at the rate of 300 to 500 trees per day by each recorder.

TREE RENEWAL

The term "tree renewal" is here used to mean growing new tops on established trees. In orchards which have been neglected or improperly treated the trees often show evidences of poor physical condition, with low and inferior production. In many such instances tree renewal with improved cultural conditions has resulted in the development of vigorous new tops and greatly improved production. This treatment will not change the type of trees of inferior strains, but will often benefit old or diseased trees or those whose growth has been retarded by unfavorable cultural conditions. Tree renewal is also generally beneficial to trees which have been girdled.

⁷ A. D. Shamel. *Citrus-fruit improvement: How to secure and use tree-performance records*. U. S. Dept. Agr., Farmers' Bul. 794, 16 pp., illus. 1917.

In renewing trees two methods may be used, either gradual renewal through the removal of one or more large branches in succeeding years or complete renewal by cutting off practically all the top growth at one time. When complete renewal is practiced some of the lower horizontal or drooping growth should be left as nurse limbs until new growth has become established. The months of April, May, and June are considered the best season for this work in the Southwest. Large branches and exposed portions of the tree trunks should be protected from sunburn with whitewash.⁸

TOP-WORKING

Top-working is performed for the purpose of improving healthy trees of undesirable strains in established orchards and for changing trees from one variety to another. It is usually best to replant badly diseased or injured trees rather than to top-work them.



FIG. 12.—A tree of the Yellow strain of the Washington Navel orange eight months after the insertion of selected buds from a superior parent tree of the Washington strain. The limb at the right is the nurse limb which was left to assist in the setting and growth of the buds. (Highgrove, Calif., January, 1924)

The season best adapted for top-working varies somewhat with local conditions, but normally the period from March to June, inclusive, is most favorable. Under certain conditions part of the work may be done in the fall, particularly during September and October, the buds lying dormant until the following spring. Spring top-working is usually less costly, as the entire operation of budding and subsequent topping is done within a short period, and if the

⁸ Ordinary whitewash may be made by slaking quicklime at the rate of 10 pounds to 2 gallons of water and adding water to bring the wash to the desired consistency. Where protection is wanted for a long period "California tree whitewash" is often used, made by the following formula: Quicklime, 30 pounds; tallow, 4 pounds; salt, 5 pounds. Slake the lime, dissolve the salt in a little water, melt the tallow, and mix it with the salt solution; then add this to the slaked lime. Dilute with enough water to make the mixture flow freely.

stand of buds is unsatisfactory new buds can be inserted with little loss of tree growth.

As a rule from three to five properly spaced framework branches are used in top-working. If one bud is used on each limb it should be inserted on the outer side of the branch about 1 to 2 feet from the tree trunk. It is often desirable, particularly with older trees, to insert buds on the two sides of the limbs to insure a perfect stand, the growth from one being removed if they both live.

The budding operation is the same as in budding seedlings in the nursery, and only carefully selected buds from superior parent trees should be used. If the bark of the framework branches is very thick, as is the case with old trees, it is desirable to thin it or cut out a small section around the inserted buds. After the buds have united properly the budded limbs should be cut off about 6 inches above the buds, the cut surfaces covered with grafting wax or other protective material, and the trunks and exposed portions of the main branches whitewashed. One of the original horizontal or drooping branches of the tree may be left for a year as a nurse limb, but this practice is not essential.

After about six weeks the new growth should be cut back to about half its length, to stimulate branching and to develop a stockier framework. All growth other than that from the selected buds should be removed from time to time; otherwise the new tops may be partly composed of growth from the original trees, thus defeating the object of top-working. Figure 12 shows an orange tree eight months after being top-worked.

About a year after top-working, the ends of the old branches should be again cut back, making a sloping cut with its upper edge flush with the base of the new growth, and the cut surfaces should be protected until they have completely healed. Some propagators prefer when working with old trees to remove the entire head of the tree except a nurse limb, allow sprouts to develop on the stubs, and then bud into a few of these sprouts.

REPLANTING

In nearly all old orchards it becomes necessary from time to time to replace badly diseased or injured trees. Recent experience has shown that young trees can be successfully replanted in such places if proper attention is given them.

The trees to be replaced should be taken out several months in advance of planting the new ones, digging a large hole and spreading the soil in a thin layer to expose it to the sun and air. The new trees can be planted to best advantage in the late spring or early summer, preferably using fresh surface soil mixed with well-rotted manure to refill the holes. The trees should be thoroughly watered as soon as they are planted, and special arrangements should be made to keep the soil moist and in good tilth until they become fully established.

To prevent undue competition with neighboring trees, trenches should be dug at least 2 feet deep and 6 or 8 feet long midway between the young and the adjacent older trees. Manure or other organic matter should be applied in these trenches, which should then be filled with soil.

TRANSPLANTING BEARING TREES

It sometimes becomes necessary to transplant bearing trees to new locations. While trees up to 50 years of age have been successfully moved, it is probable that it can be most economically done with those that are not more than 10 or 15 years old. Only healthy and productive trees are worth transplanting in commercial practice.

The best season for this work is during the early spring, though it can be done successfully up to midsummer, especially if the roots are balled. The tops of the trees should be cut back to about the same extent as for top-working, the larger cuts covered with grafting wax or other suitable material, and the trunks and remaining limbs whitewashed to protect them from sunburn.

Both the bare-root and balled systems of transplanting have been successfully used, but on account of its comparative simplicity and economy the former is usually preferred. With trees up to about



FIG. 13.—Unloading 6-year-old Valencia orange trees for transplanting; also part of a 100-acre planting of these trees. Later observations showed that trees planted with bare roots as late as this made a better start if cut back more severely. (Santa Paula, Calif., July 27, 1922)

10 years of age a trench about 3 feet deep is dug around each tree, leaving a ball of earth about 5 feet in diameter. The soil of this ball is then carefully removed from the roots with a pointed bar and the taproots are cut about $2\frac{1}{2}$ feet below the surface. The roots should be kept moistened and covered with wet sacks to protect them from drying. Figure 13 shows 6-year-old Valencia orange trees being unloaded for transplanting and a portion of a 140-acre orchard of the trees soon after they were planted.

Individual trees in older orchards sometimes show signs of decadence, with light-colored leaves and partial defoliation. This condition has been found in some instances to be associated with weak, diseased roots or abnormal bud unions and can frequently be corrected by inarching sour-orange seedlings into the trunks of the affected trees. Girdled trees and those having other serious bark wounds can also be successfully treated by inarching as well as by bridge grafting.

An improved method for doing this work which has been successfully used for several years has recently come to the attention of the writers and is illustrated in Figure 14. One or more 1 or 2 year old balled seedlings are set in holes near the tree trunk. A narrow vertical strip of bark about 12 to 15 inches long is carefully removed from the trunk of the affected tree above the bud union, and the top



FIG. 14.—Inarching a sour-orange seedling with balled root in a decadent Eureka lemon tree. Note the equipment at the right to keep the grafting wax soft. (Corona, Calif., July, 1921)

of the seedling is cut off at a point slightly higher than the upper end of this wound. The side of the seedling next to the old tree is then shaved off, beginning opposite the lower end of the wound, and the stem of the seedling is nailed in place in the wound with the cut surface of the seedling in contact with the cambium layer of the tree, the upper end of the seedling being placed under a flap of the bark. The wound and the stem of the seedling are then painted with

warm grafting wax, a strip of waxed cloth is placed over the entire wound, and another coating of grafting wax is applied.

This practice provides two long surfaces along which union of the tree and seedling may take place instead of the small area allowed by the method which has been generally used heretofore, insuring a more certain and complete union and the earlier recovery of the tree. This long-contact method can also be used in bridge grafting.

FROST PROTECTION

Practically all present citrus districts are subject to occasional frost damage unless protection is provided, but hillside orchards and those located on slopes or in the path of air currents are usually



FIG. 15.—A lemon tree defoliated by frost, with orange trees behind it only slightly injured. The lemon tree was whitewashed with a power spray outfit as soon as the damage became apparent, in order to protect the trunk and limbs from sunburn. (San Dimas, Calif., April, 1922)

less liable to injury than those on low and level lands. Frost protection is expensive, and the efficient handling of frost-fighting equipment requires careful organization of labor and constant vigilance during cold weather, hence, other things being equal, it is very important to locate citrus orchards where they will be likely to be least injured by low temperatures.

Of the citrus fruits, the orange and grapefruit are about equally susceptible to frost injury, while the lemon is more tender and the lime is most easily injured by frost. It is a common practice to have lemon orchards equipped for frost protection in areas where adjoining orange groves are left unprotected, for the reason that the expense involved in protecting the oranges would not be justified on account of the less frequent danger of loss. Figure 15 shows a

lemon tree entirely defoliated by frost while there was practically no damage to the foliage of the orange trees behind it.

The equipment for frost protection in common use consists of oil heaters, torches for lighting them, and storage tanks for extra supplies of oil. The kind and capacity of the heaters to be used depend upon local conditions, but they should be large enough to hold sufficient oil to burn at least 12 hours, constructed to burn with little or no smoke, and arranged so that the fires can be quickly lighted and extinguished. Iron heaters are liable to rust and depreciate rapidly unless they are protected with asphaltum or other covering. It is usually desirable to clean and dip or paint the heaters after the period of frost danger is over and store them, so they will not be injured. Some growers leave the heaters in the orchard during the summer, placing them in the tree rows or under the trees out of the way of orchard operations.

Torches holding about a gallon and burning a mixture of gasoline and distillate or coal oil are ordinarily used for lighting the heaters, and an ample supply of them should be on hand for emergencies.

Oil tanks should be large enough to hold sufficient reserve for maximum periods of low temperatures. Three times the capacity of the heaters is considered necessary to be safe in possible emergencies, and unless the grower is equipped for an emergency he is liable to find that all his equipment and previous efforts in frost fighting are a dead loss. Oftentimes a number of small growers maintain a storage tank in common. It is desirable to locate the tanks so that oil can be put into and drawn from them by gravity flow. Tank wagons are used in distributing oil to the heaters, and in large orchards the oil is frequently piped to various central points to reduce the haul in filling the heaters.

In order to use frost-protection equipment most efficiently it is necessary to have warning of impending frost. Growers usually make frequent readings of the temperatures in their orchards during times of danger, but in some cases community organizations provide men who obtain systematic readings from reliable thermometers in the coldest areas in their districts and give warning before the danger point is reached. Sometimes automatic frost-alarm equipment is used, which rings a warning bell when the temperature drops to any predetermined point. Normally the time of lowest temperature is just before sunrise.

It is often essential to light the heaters quickly, and enough men should be available to do this work rapidly. When the danger has passed the fires are put out by replacing the covers on the stacks. The heaters should be inspected after every burning and refilled if necessary. If it becomes necessary to refill the heaters while they are in use, it should be done by extinguishing and filling a part of them at a time.

The most efficiently protected orchards are equipped with a heater for every tree, but in some cases fewer may be sufficient. The heaters are usually set on the intersections of the diagonals of the tree rows, as shown in Figure 16, to avoid burning the trees or fruit. In many cases extra heaters are placed in the path of prevailing cold-air currents and along exposed sides of the orchards.

If trees are badly defoliated by low temperatures or other causes, the trunks and limbs should be protected from sunburn by coating

them with whitewash, as shown in Figure 15. Recent experience indicates that pruning frost-injured trees should be deferred for a year or so until the extent of the injuries can be fully determined. Further information on frost protection can be obtained from Farmers' Bulletin No. 1096, Frost and the Prevention of Damage by It.⁹

WINDBREAKS

The practice of growing permanent windbreaks for citrus orchards is now largely confined to localities where heavy winds occur rather frequently. In many districts windbreaks are planted to protect young orchards and are removed when the trees become larger. During recent years many windbreaks have been removed from old orchards because it was found that they were strong competitors with the neighboring orchard trees for moisture and plant food, and in a number of instances they were thought to have increased frost injury to near-by sections by obstructing the normal movement of cold air from the orchards.



FIG. 16.—Burning oil heaters in a California orange orchard for protection from frost, one heater being provided to each tree. (January, 1922)

The trees most commonly used as windbreaks include several species of Eucalyptus, the Monterey cypress, and a recently introduced tree, the athel. Formerly the California pepper tree (*Schinus molle*) was extensively used as a windbreak for citrus plantings, especially along roadways. It is no longer planted for this purpose, and many old plantings have been removed because the tree is one of the preferred hosts of the black scale, and its presence increased the difficulty of controlling the scale in near-by orchards.

⁹ United States Department of Agriculture, Weather Bureau. Frost and the Prevention of Damage by It. U. S. Dept. Agr., Farmers' Bul. 1096, 48 pp., illus. 1920.

Of the eucalypts the blue gum (*Eucalyptus globulus*) is the one generally used, because of its rapid growth and its adaptation to climatic conditions in the Southwest. These trees are planted close together and often in double rows. After they reach 25 or 30 feet in height they should be cut back to 16 or 18 feet, so as to induce a strong and dense growth for the protection of the orchard. This tree is unusually free from insect pests or diseases, but is a heavy surface feeder, retarding the growth of near-by orchard trees. The desert gum (*E. rudis*) is sometimes used in preference to the blue gum, as it is thought not to be such a gross surface feeder. The red gum (*E. rostrata*) is a valuable windbreak, especially resistant to drought, which withstands intense heat and is more resistant to frost than the blue gum, but somewhat slower growing. The manna gum (*E. viminalis*) is a hardy species and ranks next to the blue gum in rapidity of growth.

The Monterey cypress (*Cupressus macrocarpa*) makes an extremely desirable windbreak in many sections, because of its low, spreading, dense growth and its resistance to unfavorable climatic conditions. It is usually planted closely in single rows, requires little or no pruning, is free from insect pests and diseases, and is considered less injurious to near-by citrus trees than the eucalypts.

The athel (*Tamarix aphylla*) is exceptionally rapid growing, with dense evergreen foliage, gray green in color, and seems particularly adapted to hot, arid districts, such as the Coachella Valley. It is free from insect pests and diseases so far as known and apparently does not compete as seriously as the eucalypts with adjacent citrus trees except in light sandy soils where the water table is low.

In order to prevent the injurious effects of windbreaks in robbing adjoining orchard trees of soil moisture and plant food, it is desirable to plow deep trenches or to subsoil in the area between the windbreaks and the citrus trees. This trenching or subsoiling should be deep enough to cut the feeding roots of the windbreak trees and frequent enough to prevent their renewed growth from becoming competitive.

CITRUS DISEASES, INSECTS, AND OTHER PESTS

Citrus trees and fruits in the Southwest are subject to serious injuries by a considerable number of diseases and pests, which can be successfully controlled by proper treatments. Information regarding these troubles and methods for their control can be obtained from the Department of Agriculture, Washington, D. C., from the California Citrus Experiment Station, Riverside, Calif., the Arizona Agricultural Experiment Station, Tucson, Ariz., or from local county agents.

HARVESTING AND MARKETING THE CROP

The harvesting and marketing of the citrus crop are specialized operations generally conducted by carefully trained groups rather than by the growers themselves. Extensive investigations by the Department of Agriculture have demonstrated that most of the ordinary decay that is found on citrus fruits in transit and on the markets is the result of improper methods of handling in the various

harvesting and packing operations. Careful handling has thus been shown to be a fundamental requirement in all operations of preparing the fruit for market.

A large part of the fruit shipped from the Southwest is picked by crews hired by the packing houses and carefully trained to do this work properly and economically. Approximately 85 per cent of the crop is marketed through nonprofit cooperative associations of the growers. Except in the case of a few owners of large plantings, the fruit is prepared for shipment in central packing houses, as shown in Figure 17, which are operated by the cooperative associations or by independent jobbers or commission dealers who direct the shipment and sale of the fruit from their houses. A few growers of large acreages pack and ship their own fruit, which is usually marketed by eastern agents.



FIG. 17.—Interior of a lemon packing house, showing workers in the foreground grading fruit from the storage boxes onto shallow trays from which it is packed, as shown in the center. The equipment for orange handling is located at the opposite side of the room. (Corona, Calif., 1922)

Detailed information regarding proper methods of picking, handling, and shipping citrus fruits may be obtained from the U. S. Department of Agriculture, the State experiment stations, or the local county agents.

LABOR CONDITIONS

Labor for the production and handling of the citrus crop may be divided into two classes, ranch and packing house. These classes are not separated by any hard and fast lines, inasmuch as workers are often changed from one kind of work to another, as circumstances make necessary.

Ranch employees include teamsters, autotruck or tractor drivers, irrigators, pickers, pruners, fumigators, and the like. Here, again, the employees often perform different kinds of works at different

periods, but on large ranches they are engaged on one kind of work more or less continuously. On the other hand, on small citrus properties the owner or a few employees may perform all or most of the work, except possibly the picking or fumigating, which is usually done by trained crews.

Packing houses handling lemons are in almost continuous operation throughout the year, but those packing only oranges and grapefruit are closed for a part of the year, in which event the male employees are frequently used for orchard work. Women frequently perform the grading and packing operations.

Ranch employees are generally paid by the day or month, but in certain work they are often hired on a piecework or contract basis. In some kinds of labor requiring particular care or skill wages are often increased by a bonus for more or better work. Teamsters, tractor drivers, irrigators, pickers, pruners, and some other classes of labor are usually paid by the month. Pruners are sometimes paid on a piecework basis, and fumigation and pruning are often contracted with outside labor at a fixed unit rate. Wages vary to some extent with the kind of work, locality, season, or other conditions but are comparatively stable and satisfactory.

Packing-house labor is usually paid on a day basis, except that packers are frequently paid by the box, and the making and lidding of boxes and loading them into cars are sometimes contracted on a unit basis.

During recent years a great deal of attention has been paid to housing accommodations for employees of citrus ranches and packing houses. Houses and gardens are often provided for families, and in many cases recreation rooms, tennis courts, baseball diamonds, or other means of entertainment are supplied. The effect of this development has been to attract and hold a superior class of labor, and it has been found to be an efficient and economical method of maintaining satisfactory labor conditions, especially in small towns or on isolated ranches. The California Fruit Growers Exchange has established a labor bureau to assist growers in securing desirable employees and in improving their living conditions.

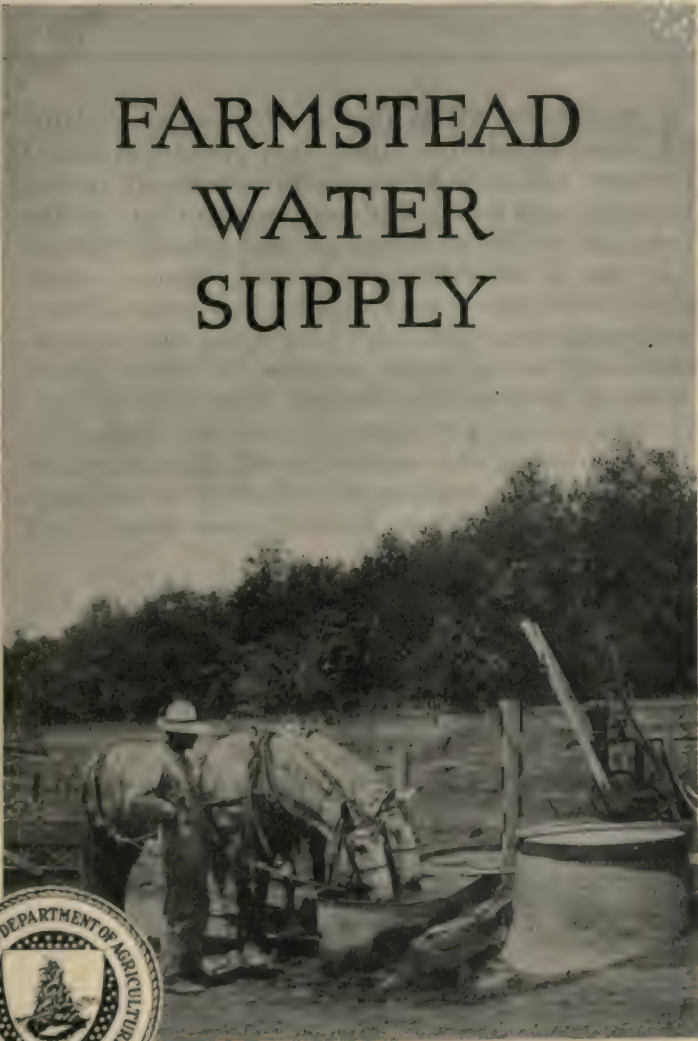
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1448

FARMSTEAD WATER SUPPLY



U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN NO. 941

A WATER SYSTEM that shall provide a whole-
some supply for family use, prove serviceable
for farm purposes, be as nearly permanent as may
be made, and cost as little as possible is one of the
principal utility problems of the average farmer.
The aim of this bulletin is to give farmers, county
agents, and others information concerning sanitary
and engineering principles underlying safe, service-
able, and lasting water systems for farm homes.
Study of the problems involved should always pre-
cede the spending of money for labor or equipment.
The importance of a well-conceived plan can not be
overestimated. Haphazard methods and makeshift
devices result in waste, dissatisfaction, danger, and
abandonment.

This bulletin supersedes Farmers' Bulletin 941,
Water Systems for Farm Homes.

Washington, D. C.

Issued August, 1925

FARMSTEAD WATER SUPPLY

By GEORGE M. WARREN,

Hydraulic Engineer, Bureau of Public Roads

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INTRODUCTION

FARM WOMEN say their greatest need is to have water piped into the house, especially to the kitchen sink. To draw water by turning a faucet does wonders to lighten the work and revive the spirits of the housewife. Farm men find running water no less convenient. No other utility is so often used. If the water is pure, no other utility does so much to promote the health of both man and stock.

The 1920 census reports 1 out of 10 farms in the United States as having water piped into the house. Vermont and California have the highest percentages, 62.9 and 56, respectively. Arkansas and Mississippi have the lowest percentages, 0.8 and 1.1, respectively. Illinois has a percentage of 11.2. In the latter State a recent canvass of about 1,200 rural and urban houses in 14 counties shows that at 546 homes water is carried to the house and at 206 it is carried to the barn; at 602 homes water is pumped to the house and at 106 it is pumped to the barn; 845 homes have sinks and 358 have none; 599 homes have a laundry on the first floor; 464 homes have a men's wash room outside the kitchen; 428 homes have bathtubs with running hot and cold water. These statistics indicate how vast the undeveloped field is. Figures 1 and 2 show clearly how much it means to have running water in and about the farm buildings.

PURITY OF FARM WATERS

Purity of the water supply should be the first consideration of the farmer, though the fact is seldom realized until sickness or death visits some loved one. Disease germs can not be seen with the naked eye and thousands may lurk in a drop of water or in a particle of waste matter the size of a pinhead. From specific germs or parasites that may at any time exist in contaminated water there



FIG. 1.—No water in the home makes steps and labor. Running water saves time and drudgery. A, Farm woman dipping water from a spring, Virginia; B, carrying water to the house; C, doing the family wash; D, farm woman pumping water, Wisconsin; E, farmhand hauling water, Alabama; F, concrete watering trough and heater, Maryland; G, corner of a kitchen supplied with running water in a log farmhouse, Virginia; H, watering trough on a sheep ranch, Idaho; I, plenty of drinking water for man and beast, Indiana

may result typhoid fever, dysentery, diarrhea, or intestinal worms, of which the hookworm, roundworm, whipworm, eelworm, tapeworm, and seatworm are the more common. Contaminated water may contain also the causative agents of numerous ailments common to livestock, such as tuberculosis, hog cholera, anthrax, glanders, and stomach and intestinal worms. Disease germs are carried by many agencies and are unsuspectingly received into the body. A few cases are cited herewith:

In 1911 the water of a nicely located and apparently tightly covered dug well in Virginia began to smell and taste foul and become the cause of intestinal disturbance. Examination disclosed 16 live frogs and 6 more or less decomposed. After the well had been cleaned and pumped out several times, the water was entirely satisfactory.

In 1914 90 cases of typhoid fever and 7 deaths in California were caused by a water supply contaminated by a septic-tank discharge which drained a long distance above ground and then through 141 feet of gravel.

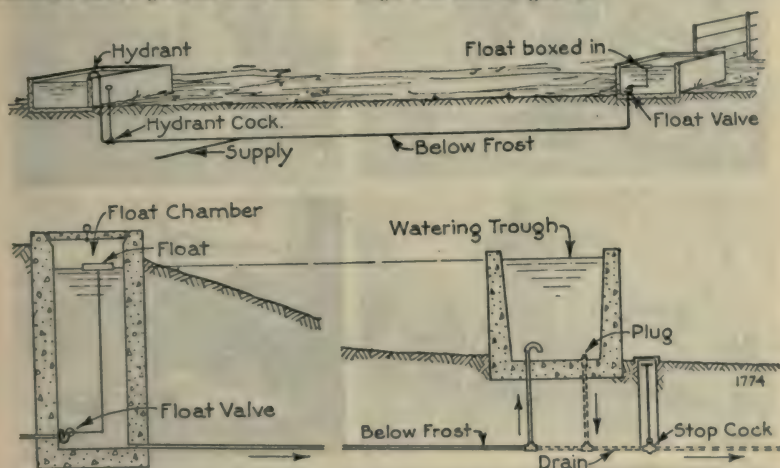


FIG. 2.—Methods of piping water to troughs. Upper left trough supplied from a simple anti-freezing field hydrant. Upper right trough automatically supplied by a float valve. Below, anti-freezing float chamber from which water may be automatically supplied to one or more troughs set to have the same water level; dotted pipes show how system may be drained.

In 1915 a heavy rain gorged a house sewer in Virginia, whence some water escaped to the pit at the top of a drilled well and followed down the casing. Within 14 days five of the eight children in the family were stricken with typhoid fever and the eldest died.

Surveys indicate that three out of four farm water supplies are sufficiently polluted to be unsafe. Streams, ponds, irrigation ditches, and other surface supplies are sure to receive pollution, either directly or from surface wash. Wells and springs are polluted through the open or loose top and by foul drainage under ground. Figures 3 and 4 show some of the ways by which farm water supplies become polluted and dangerous.

SAFEGUARDING THE WATER SUPPLY

Tight well platforms and casings, clean grounds, and wide separation of the well from probable channels of impure drainage are the greatest safeguards. It is not enough that a well or spring

is situated 50 or 150 feet from a source of filth or that it is on higher ground. Given porous ground, a seamy ledge, or long-continued pollution of one plat of land, the zone of pollution is



FIG. 3.—How springs and wells become polluted. A, Open spring; noxious substances are washed in by rain and carried by wind; vermin has free access; vegetable growths develop in the water; B, the favorite well of old is a menace; dust and bacterial life find lodgement; filth from the hands clings to the chain and bucket; C and D show wells having loose, unsafe platforms; pollution by surface wash, filth from shoes, droppings from poultry, worms, bugs, toads, mice, or other animal life; E, well between barn and hog wallow; F, well badly polluted by drainage from near-by privy

likely to extend long distances, particularly in downhill directions. A well may draw pollution from lower ground, particularly when drought and heavy pumping depress the water table enough to re-

verse the direction of drainage movement. Only when the surface of the water in a well or spring is at a higher level at all times than any near-by sources of filth is there assurance of safety from impure seepage. Figures 5, *A*, *B*, and *C* and Figure 6 show well-protected water supplies; additional safeguards are shown in Figures 14 and 15. Figure 7 shows in striking manner what good water means to a community.

CHARACTERISTICS OF GOOD WATER

Water for domestic use should be clear, colorless, odorless, soft, neither strongly acid nor alkaline, and its temperature for general farm purposes should be about 50° F. These characteristics, however, must never be deemed proof of purity, for a glass of water

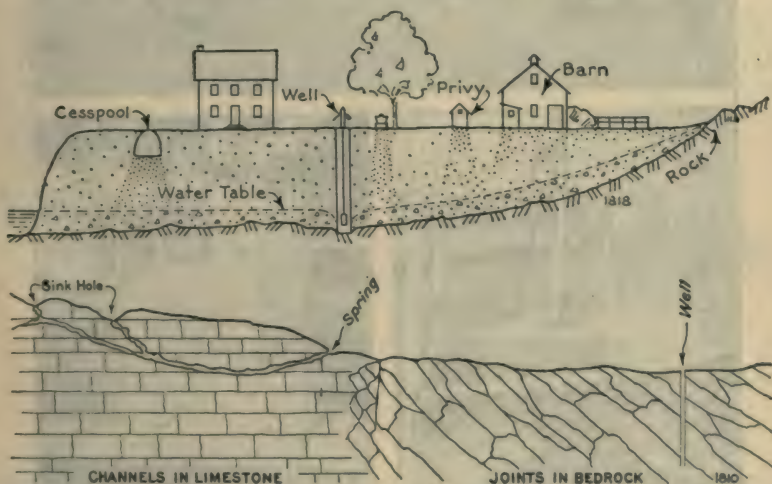


FIG. 4.—How foul drainage reaches wells and streams. Below: Characteristic openings in rock formations; sink holes and channels dissolved in limestone; jointed or broken condition in the upper portion of granite and other kinds of bedrock; the farm wastes should never be thrown or discharged in sink holes or other rock openings

may possess them all and yet contain millions of disease-producing germs. Any suspicious water should be rejected or disinfected (see *Disinfection of Drinking Water*, page 10) until both the water and the surroundings where it is obtained are passed upon by competent sanitation authority, such as the town, city, county, or State board of health.

CONSUMPTION OF WATER

Higher standards of living are everywhere creating new and increased demands for water. A bath requires 30 gallons, and each flush of a toilet takes 4 to 6 gallons. Heavily worked horses and mules and milk cows may consume 20 to 25 gallons per day in hot weather, and with all farm animals conditions of weather, food, and living may double or halve the ordinary requirements. Table 1 shows fair allowances.

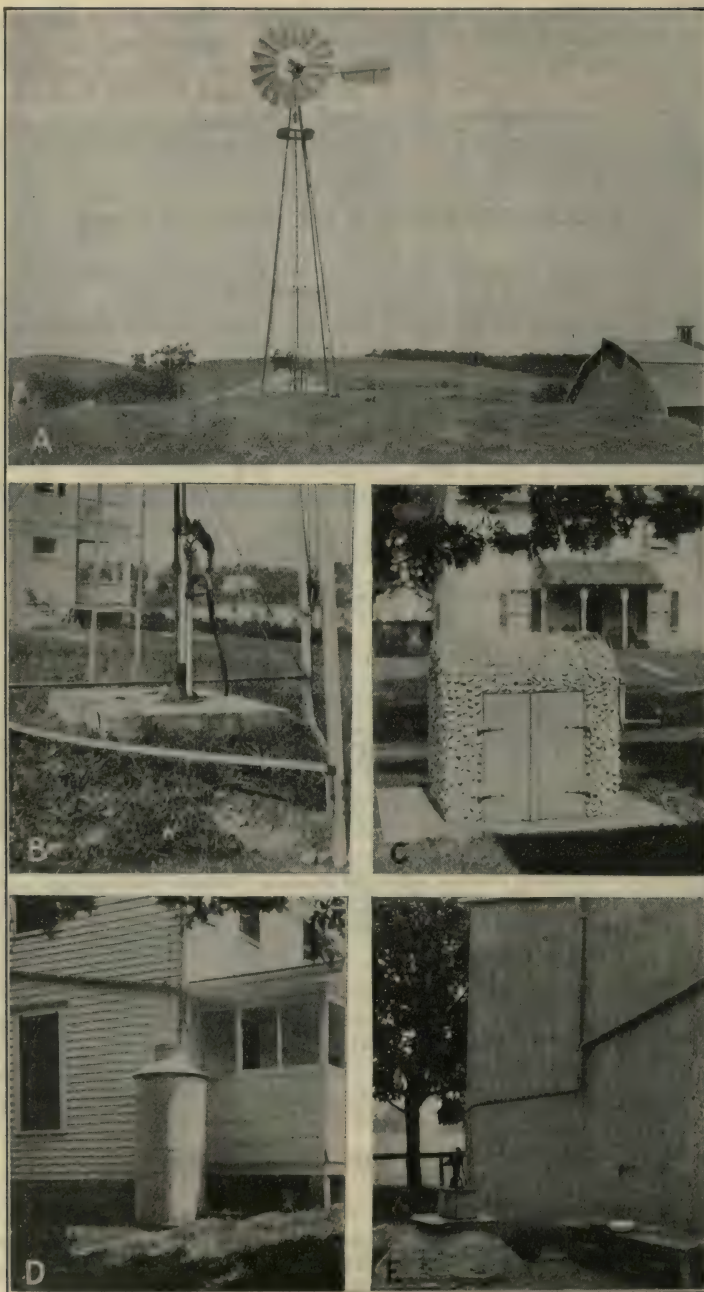


FIG. 5.—A, Favorable location for well; clean ground above or to one side of impure drainage from buildings; B, tight concrete platform with raised and sloping top and pump securely bolted to it; C, protection of an old well, Maryland; D, galvanized steel cistern objectional because the water dissolves more or less zinc, is warm in summer and freezes in winter; E, loose rubble masonry cistern; water liable to pollution from surface wash and underground seepage

TABLE 1.—*Water requirements of farms and schools*

[Gallons per person or animal for 24 hours]

Water use	Quantity
	Gallons
Domestic purposes, 1 pump at kitchen sink.....	4-8
Domestic purposes, 1 faucet at kitchen sink.....	7-15
Domestic purposes, running hot and cold water in kitchen, bathroom, and laundry.....	20-25
Sprinkling and cooling purposes, outdoor washing, leakage, etc.....	15
Average daily consumption, modern home.....	40
Maximum daily consumption, modern home.....	100
Schools, 3 to 15 gallons, average.....	7
Horse, mule, or cow.....	12
Sheep or hog.....	1

CISTERNS

Rain water is soft and comparatively pure, but when collected in cisterns often contains polluting matter. The evils of cistern water relate to the uncertainty of rainfall; to freezing in winter and unwholesomeness in summer; to entrance of dust, soot, bird droppings,

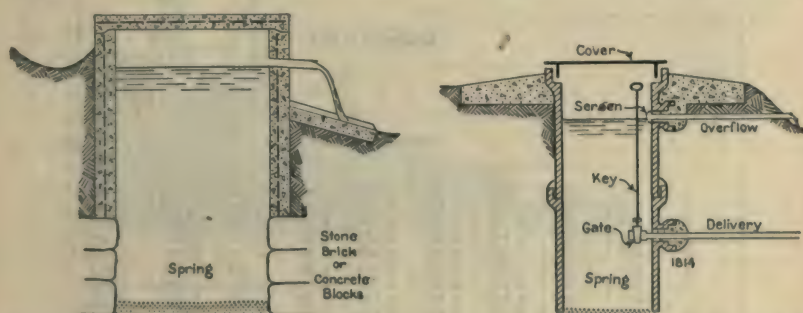


FIG. 6.—Protection of springs. Curbed and covered to keep out surface wash and to prevent dipping or bailing; water should be drawn only by natural flow through a pipe or by pumping; on the left, square concrete box having 4 or 5 inch walls and 3 inch top reinforced with heavy wire netting or stock fencing; on the right, curb composed of large-size clay or concrete pipe (T branches)

and vermin from the roof; to objectionable taste from metal and concrete walls or from growth and decay of certain organisms in the water; to neglect in cleaning; and to poor construction resulting in loss of water or entrance of tree roots, or, what is frequent and more serious, foul seepage from a nearby source of filth. Figures 5, *D* and *E* show cisterns that should not be used for drinking water.

The vital features of a cistern for potable water are: (1) Absolute water-tightness, top, sides, and bottom, and close screening of inlet and waste pipes; (2) provision for excluding from the cistern the first portion of each rainfall until the roof or other collecting area has become rinsed thoroughly; (3) a first-class filter of clean, well-selected sand and thoroughly burned charcoal; (4) a waste pipe which removes surplus inflow from the bottom of the cistern where impurities tend naturally to settle; (5) periodic and thorough cleaning of the cistern and filter; (6) no connection between the waste pipe and a sewer or a drain which may carry impure drainage.

To determine the quantity of water falling on roofs: Measure horizontally in feet the ground plan of the roof and compute the area of the ground plan in square feet. Multiply this area by the rainfall in inches (for the wet-weather period¹ which must supply the desired storage) and divide the product by 1.6. The result is the number of gallons of water. The householder who would avoid the inconveniences of a shortage in his cistern supply is fully warranted in planning a large installation. Most localities experience long droughts or exceptionally dry years when rainfall drops to one-half or one-third of the normal. Moreover, many small rains may be impracticable of collection because of the dirty condition of the roof.

To find the capacity of square or rectangular cisterns and tanks: Multiply the inside length by the breadth and the product by the height, each dimension being in feet. Multiply the result (cubic feet) by $7\frac{1}{2}$ to find the gallons. Gallons divided by $31\frac{1}{2}$ give barrels. Table 2 shows the capacity of round cisterns of certain dimensions.

TABLE 2.—Capacity of round cisterns and tanks

Depth in feet	Diameter in feet								
	4	5	6	7	8	9	10	11	12
	Capacity in gallons								
4	376	588	846	1,152	1,504	1,904	2,350	2,844	3,384
5	470	735	1,058	1,439	1,880	2,380	2,938	3,555	4,230
6	564	881	1,269	1,727	2,256	2,855	3,525	4,265	5,076
7	658	1,028	1,481	2,015	2,632	3,331	4,113	4,976	5,922
8	752	1,175	1,692	2,303	3,008	3,807	4,700	5,687	6,768
9	846	1,322	1,904	2,591	3,384	4,283	5,288	6,398	7,614
10	940	1,469	2,115	2,879	3,760	4,759	5,875	7,109	8,460
11	1,034	1,616	2,327	3,167	4,123	5,235	6,463	7,820	9,306
12	1,128	1,763	2,537	3,455	4,512	5,711	7,050	8,531	10,152

Wood cisterns are objectionable because of their short life, probability of leaking, and tendency to promote bacterial growth; they cost about as much as steel or masonry. Brick cisterns are generally circular, with walls about 8 inches thick. The joints should be completely filled with cement mortar and both the inside and outside surfaces should be left rough to receive heavy plastering coats of rich Portland cement mortar. The inside should be troweled while green to produce a hard impervious surface. Concrete cisterns may be square or round, the latter, for a given capacity, requiring a little less material, but more labor in building the form. Information on mixing and placing concrete and plastering coats to secure watertightness is given in other bulletins² of the Department of Agriculture.

¹ The amount and the seasonal distribution of rainfall at the principal cities throughout the country may be obtained from the U. S. Weather Bureau, Washington, D. C., from local forecasters in the several States, and from published reports of the Weather Bureau in many libraries.

² Yearbook Separate 824, *Securing a Dry Cellar*, Farmers' Bulletin 1279, *Plain Concrete for Farm Use*, and Department Bulletin 230, *Oil-Mixed Portland Cement Concrete*. The first two are mailed free on request by the U. S. Department of Agriculture and the last may be obtained for 10 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Before putting a masonry cistern to use the inside walls should be allowed to air and cure for a month or more and be occasionally sprinkled with water to convert the free lime in the cement to carbonate of lime, which is only slightly soluble in pure water. A new cistern should be pumped out two or three times prior to use of the water for drinking. With continued use of a cistern dissolved mineral matter ceases to be of importance.

FILTERS

Filters should operate slowly—like rainfall percolating into the ground. The rate of filtration should not exceed 50 gallons in 24 hours for each square foot of effective area in the filter bed; the rate is readily controlled by placing a valve in the pipe from the filter to the cistern, opening or closing the valve as necessary. The water

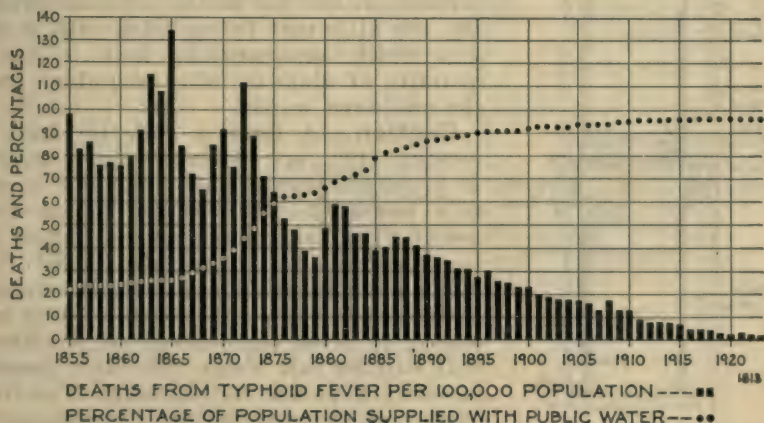


FIG. 7.—Typhoid-fever death rate and percentage of the population supplied with public water (good water) in Massachusetts from 1855 to 1923; notice the rise of the dots and the drop of the vertical bars; in 1923 fully 96 per cent of the people were supplied with public water, and the typhoid-fever death rate had declined to 1.8 per 100,000 population; though many agencies contributed to this notable decline, unquestionably good water is a leading one

level should be maintained above the filtering material, thus protecting the film of silt and mud on the surface of the filter. It is in this film and a thin layer just below it that most of the filtering is done.

Sand is one of the best and most available filtering materials, and well-burned wood charcoal, the pieces averaging the size of wheat grains, is useful in removing color, taste, and odor. Clean pit or beach sand or crushed quartz is much used. Where the water to be filtered is relatively clear (like rainwater) the sand should be very fine. For surface waters carrying sediment, slightly coarser sand, such as is used in plastering work, is generally used. A depth of 2 feet of carefully selected, uniform size sand, washed to remove all clay, silt, loam, and vegetable matter, is preferable to a greater depth of poor sand. As the thin surface layer becomes clogged with continued use it may be scratched or furrowed or a half inch may be scraped off with a trowel, until eventually the bed is reduced to 12

or 15 inches in thickness. The sand removed should be washed and returned, or be replaced with new sand.

Figure 8 shows a simple home-made slow sand filter having a capacity of 25 to 30 gallons per 24 hours. It can be made by any handy person for about \$10. Figure 9 shows the important features of a filter and cistern to care for roof water. Figure 10 shows an arrangement to clarify water from an irrigation ditch.

The foregoing filters are of the gravity or open type. They operate by natural flow at slow rates and under low heads. Pressure or closed filters are on the market. They may be placed conveniently in the home and be connected with the discharge pipe from a pump or other pressure supply. The filtering material may be a natural product such as tripoli stone or sand and charcoal. If the water is discolored and contains matter too fine to settle on standing, the filter may be provided with a device which automatically feeds a small quantity of alum or other coagulant into the unfiltered water.

Caution.—A filter is a device for removing dirt or sediment from water. It promotes purity and safety but never is a guaranty. It does not excuse the use of water taken from sources known to be contaminated. Filtration alone does not materially affect such dissolved minerals as the water may contain. For instance, if brine be filtered, the resultant will still be salt water. A filter should be easily accessible for cleaning. The frequency of cleaning depends on the dirtiness of the water and the use of the filter. Dirty sand can be washed, but dirty

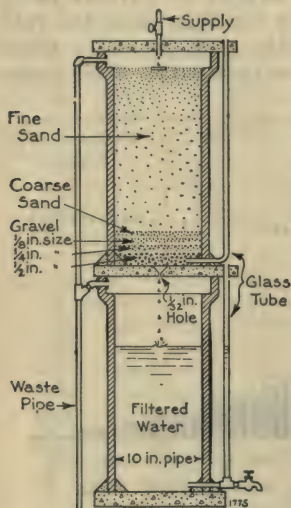


FIG. 8.—Homemade slow sand filter

charcoal should be replaced with new charcoal. Charcoal filters, if neglected, may become a detriment rather than a benefit, due to the storage and overloading of organic matter within the pores and upon the surface of the charcoal.

DISINFECTION OF DRINKING WATER

Disinfection (destruction of disease germs) of drinking water by home methods should be considered an emergency measure. The purity of a cistern, spring, well, or surface water is often suspected before the existence of disease becomes definitely known. Suspicion may be created by minor intestinal ailments or by odor or taste of the water. Pending examination of the water supply by competent sanitation authority, the householder should stop using the water for drinking and cooking or employ some method of disinfection. Where chemical disinfection is employed, great care should be used in preparing the chemical, keeping it on hand, and adding it to the water. Directions should be followed explicitly. Stock solutions should be kept where children can not get them and bottles should be plainly labeled "Stock Solution for Disinfecting Water—Poison".

It is very important to understand that, even though printed directions are closely followed, disinfection processes are not always complete. Waters of varying physical and chemical composition react differently with equal quantities of a given chemical, similarly as two individuals may be differently affected by like doses of medicine. Clear water is usually more readily disinfected than muddy or cloudy water. Well or spring waters may, however, be clear and sparkling and yet contain so much ferrous iron, nitrite nitrogen, or other oxidizable matter as to be little affected by an ordinary dose of the chemical disinfectant. The sediment in a muddy water or the oxidizable constituents, if such be present, in a clear water uses up the chemical before germicidal action takes place.

Chemists and bacteriologists by laboratory experiments determine the exact amount of disinfectant for each particular water and its action on the germs therein. These matters are guesswork with the average individual. He may guess wrong, and his efforts to disinfect drinking water may lead to a false sense of safety. For these reasons absolute reliance can not be placed upon home methods of sterilizing water with chemicals. As a temporary precaution against disease, such methods may serve a very great service. Two methods of disinfecting drinking water recommended by the Bureau of Chemistry are as follows:

(1) *Disinfection with chloride of lime.*—Pre-

pare a chloride of lime solution by dissolving 1 teaspoonful of fresh chloride of lime (bleaching powder) in 1 quart of water. Place this stock solution in a stoppered bottle. Such a solution gradually loses its strength, and fresh solutions should be made up occasionally. For disinfecting water, mix thoroughly 1 teaspoonful of this solution with 2 gallons of water. After 30 minutes the water will usually be fit to drink.

(2) *Disinfection with tincture of iodine.*—This drug is an excellent disinfectant for drinking water, can be obtained at any drug store, and is found in the medicine chests of most households. Ordinary tincture of iodine contains approximately 7 per cent of iodine. Mix 1 drop of this tincture thoroughly with 1 quart of water. The

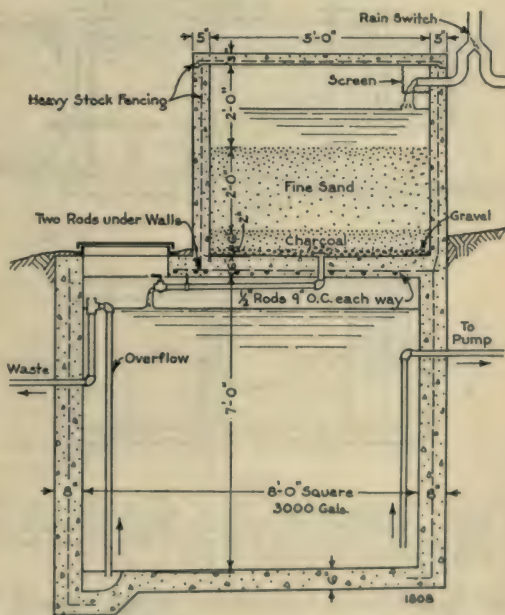


FIG. 9.—Working drawing for a square filter and cistern to hold about 3,000 gallons; estimated cost \$150 to \$250

water so treated will usually be safe for drinking purposes after 30 minutes have elapsed. Proportional mixtures for other quantities of water are as follows: 11 drops of tincture in $2\frac{3}{4}$ gallons of water (an ordinary pail full), 1 tablespoonful or 3 teaspoonfuls of tincture in 52 gallons of water (a large barrel, approximate inside middle diameter 24 inches, end diameters 20 inches, depth $30\frac{3}{4}$ inches).³

SURFACE-WATER SUPPLIES

Streams, ponds, irrigation ditches, and small open reservoirs are unsafe sources of farm water supply. The temperature of such water seldom is satisfactory, and the presence of more or less polluting matter is certain. The only safe course is to avoid drinking

water from any surface source unless such water has been disinfected.

GROUND-WATER SUPPLIES

Good ground water is the ideal supply for the farm. If uncertain of the depth, quantity, or quality of the water likely to be encountered, one should describe fully the location and conditions to the United States Geological Survey or to State geological authorities and ask for advice. Many wells have been sunk to great depths in

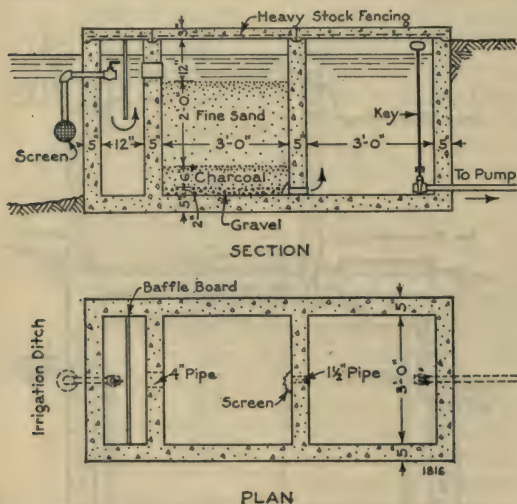


FIG. 10.—Working drawing for a cistern and filter to clarify water from an irrigation ditch; cistern holds 225 gallons; capacity of filter about 450 gallons per 24 hours; estimated cost \$75 to \$125

the belief that a plentiful supply would be reached, only to find no water, or that it was unfit for use, or that a mere hole had been created which served only to drain water from relatively near the surface. Information as to the kind, thickness, porosity, and dip of the strata of the region, the results obtained in neighboring wells, and examination of the land slopes, vegetation, and evidences of seeps and springs serve as good guides in locating water supplies. There is little to recommend certain patented electrical water finders or the use of a forked willow, hazel, or peach stick, although so-called forked-stick artists, from their experience and observation of surface conditions, usually are better able to judge of the probabilities of ground water than is the average person.

³ Two other methods often used to disinfect drinking water are as follows:

(1) Boiling water 20 minutes. This is a very safe method but is inconvenient for large quantities of water or where the method must be employed for a considerable period of time.

(2) Disinfection with tablets containing a compound of chlorine. This method is simple and convenient, as suitable tablets with directions for using may be purchased at many drug stores.

The most likely appearance of seeps and springs is near the base or toe of slopes. Shallow wells thus located usually are stronger than those higher up the slope or farther out on the flats. Wells upon the crown of a hill or close to rock outcrops are not likely to yield plentifully. The stronger artesian flows usually come from the lower strata.

Sands, gravels, porous sandstone (consolidated sand), and conglomerates (consolidated gravel) are the most promising water-bearing materials. Quicksand, clay, marl, and hardpan usually contain considerable water, but yield it too slowly to afford satisfactory supplies. Shale and slate (consolidated silt and clay) are not good water bearers, but water sometimes is obtained at considerable depths from the joints and cleavage planes. Granite, gneiss, and schist (rocks formed or modified by heat) are likely to be hard and impervious, but due to broken or jointed condition (generally within 300 feet of the surface and seldom below 500 feet) may yield moderate quantities of very good water. Lava rock often yields abundantly, but generally the supply is essentially of surface origin, frequently seepage from irrigation ditches. Limestone usually carries an abundance of water within the passageways and cavernous channels which characterize this rock, but the water usually is hard and may be contaminated easily from surface sources. (See Fig. 4.)

SEEPS AND SPRINGS

Seeps and springs are the natural emergence of ground water upon the surface. Anything that reduces resistance to the flow, such as open-joint pipes or conduits for the collection of seeps or excavating and encasing a spring, tends to increase the yield. Increase of resistance through choking the flow or building up the curb to a moderate height above the natural surface tends to decrease the yield, and may cause its complete loss by deflecting it to other channels. Figure 11 shows drain tile laid to collect seeps or small springs. To prevent silt entering the tile a 6 to 8 inch wide strip of linen or burlap should be fastened around each joint. If any part of the line is in quicksand, mud, or clay, where little or objectionable water would be collected, sewer pipe should be used in that portion and the joints should be tightly made with jute and cement mortar or bituminous jointing compound to keep out fine material.

Horizontal pipes, cribs, or chambers are sometimes located beneath irrigation ditches or where water is to be taken from the margin of a pond or stream. In the latter instances it is better to locate the collector 50 or more feet from the body of water, because it is better to intercept ground water moving toward a surface supply than to draw water from it direct. Collectors may be of tile, wood, stone, brick, or concrete, and there should be ample space, particularly at the bottom, for water to enter. They should be placed below all low-water levels, lengthening them as necessary to increase the yield.

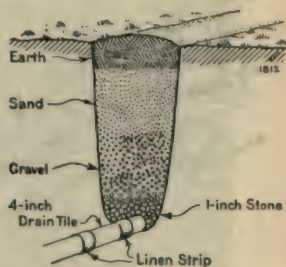


FIG. 11.—Drain tile laid to capture seeps and small springs

In many instances an elevated spring may be piped to the buildings, forming a gravity system, as shown in Figure 12. Where feasible, such a system is superior to any other kind because the water is generally good, the construction is simple, the operation is certain and the expense and bother of pumping are saved. Figure 6 shows two simple curbs to inclose and protect springs.

WELLS

Wells are artificial openings in the ground to or below the water table. They should be sunk sufficiently into the water-bearing material in order that neither drought nor maximum pumping operations of the farm shall so lower the ground water that the pump must be stopped to avoid taking air. No new well should be regarded as complete until a pumping test of proper continuous duration has been made to determine its sufficiency for the purpose of the farm and to make sure that a mere pocket of water has not been tapped. Unscrupulous contractors resort to numerous tricks when testing



FIG. 12.—Water delivered by gravity (natural flow). Note protection of the spring: a shallow trench on the upper side to divert surface water, and the site inclosed by a fence to keep out stock

wells, and these matters should have the personal attention of the farmer who pays the bill. In making the final pumping test the discharge should be taken by pipes or troughs a considerable distance from the well and to lower ground if possible.

DUG WELLS

Dug wells are open excavations, the diameter varying with the freedom with which water enters, the rates of pumping, and the requirements for water. Excavations showing the slightest indication of caving should be carefully braced to guard against accident. The usual method of digging wells is to have one or two men at the bottom to loosen the material and shovel it into a bucket which is hoisted to the surface with the aid of a windlass or tackle blocks as shown in Figure 13, *A* and *B*. Sometimes a small orange-peel bucket operated by hand with the aid of a tripod derrick is used. In loose sand yielding an abundance of water the excavation sometimes is made entirely by the use of a centrifugal pump. The lining



FIG. 13.—A. Use of a windlass in digging a well, Maryland; B. raising the loaded bucket by horse power, New Hampshire; C. hydraulic ram, Virginia; D. hydraulic ram in operation; the water which does the work is gushing from the escape valve; E. flowing wells, Utah; F. float-controlled valve for use where the flow of a spring is too small to operate a ram continuously; a 2-inch valve costs about \$10

or curb is started on a wood or steel shoe which gradually sinks as material is pumped from the bottom and curbing is added at the top.

Quicksand is a frequent source of trouble. If the material is removed by an orange-peel bucket or a centrifugal pump, flow of the quicksand may be largely prevented by keeping the excavation partially full of water, thus neutralizing the hydraulic pressure in the quicksand and rendering it comparatively solid. If the material must be excavated by hand methods, the lower or cutting edge of the sheeting or curbing should be constantly kept from 1 to 4 feet below the bottom of the excavation. Wood may be used for sheeting and steel or concrete for permanent curbing; its sides should be water-tight. Hay, straw, or fine brush is very useful to give men footing and to close temporarily small boils in the bottom of the excavation. After the excavation is completed, entry of quicksand at the bottom may be prevented by placing a thin layer of clean,

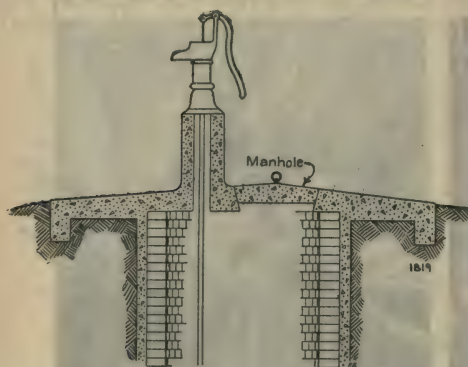


FIG. 14.—Dug well, curbed with 4-inch course of brick laid dry. One like this in Maryland, 4 feet in diameter and 23 feet deep in clay soil cost \$53.18 in 1915; manhole and cover shaped by using a large dish pan; cost includes 1,900 brick, the pail, rope, pick and shovel used in excavating, the pitcher pump which is mounted on a concrete base 9 inches square and 18 inches high

coarse sand and weighting it with several layers of sand or gravel of increasing coarseness. There is thus created a graded sand filter, each layer of which is held in position by the slightly coarser material above it.

Curbs may be of stone, brick, concrete block, or of concrete, vitrified, corrugated, or cast-iron pipe. Wood soon decays and should not be used. At least the upper 10 feet of masonry curbs should be laid in cement mortar to make it water-tight. Figure 14 shows a brick curb with the top properly protected. Considering clean-

liness, tightness, durability, and cost, perhaps no curbing is better than vitrified sewer pipe or hard-burned drain tile. Such a curb with cemented joints and a method of lowering and placing the pipe is shown in Figure 15. Sometimes the pipes are placed with the hubs downward, but such arrangement makes it impracticable to cement the joints. Sometimes the lower portion of the curb is enlarged by building up from the bottom with stone or brick laid without mortar, the masonry being arched inwardly to meet and support the pipe curbing at or near the water level. The space between the curb and the sides of the excavation should be filled with clean sand and gravel, the coarser material being placed from the bottom to the water level. The upper 10 feet may to advantage be sealed with concrete or clay. The curb should be brought at least 1 foot above the ground and be surmounted by a concrete platform in which is placed a tight-fitting iron or concrete manhole cover.

The platform should slope from the center and the earth be graded to shed pump drippings and surface water quickly.

If a pump is to set upon the platform, a block of wood or a tin can may be embedded in the concrete to provide an opening for the pipe and cylinder. A firm, water-tight joint between the pump base and the concrete is made by using expansion bolts or anchor bolts and a gasket. Expansion bolts are screwed through the pump base into holes in the concrete. Anchor bolts to fit the holes in the base are embedded in the concrete when it is placed. Ordinary bolts with the thread end up and a large flat washer on the head in the concrete answer every purpose.

If properly located, built, and protected, dug wells are more likely to be satisfactory than tubular wells. The advantages relate to longer life, softer water, and larger volume, permitting more rapid pumping, lower lifts, easier inspection and cleaning, and less trouble from quicksand and air leaks.

CLEANING DUG WELLS

Most dug wells require cleaning occasionally, due to the entrance of dust or other foreign matter at the top and to the washing in of clay and silt with the ground water. The first step should be an inspection of the curb, which if weak or defective would make entrance dangerous. This examination may be made more thoroughly by the aid of a beam of sunlight reflected into the well by a mirror. To determine the presence of harmful gases, a lighted candle or small bird should be lowered into the well. Complete or partial failure of the candle to burn, or death or exhaustion of the bird, indicates dangerous conditions for man. Thorough ventilation of the well is the best remedy.

If it is found safe to enter the well a ladder should be lowered and the curb from the top down scrubbed with wire or other stiff brushes and rinsed thoroughly. The well should then be pumped as low as possible, and any mud, moss, or other debris should be scraped

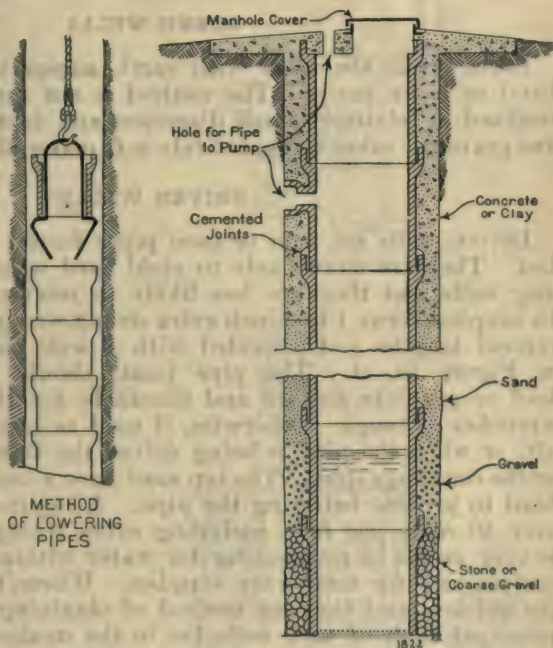


FIG. 15.—Dug well curbed with vitrified or concrete socket pipe such as is used for sewers. Wells of this kind 24 inches in diameter and 35 feet deep in sand have cost about \$200, Massachusetts.

into pails and removed. After thorough cleaning the well should be allowed to fill and should then be pumped out rapidly. This operation may be repeated to advantage two or three times. The disinfection of wells with chemicals is not recommended unless the work is done under technical direction. (See Disinfection of Drinking Water, page 10.) The volume of water must not only be estimated with reasonable exactness, but the character of the water and the proper amount of chemical should always be determined by an expert chemist. The effects of disinfection gradually disappear as water flows into a well to replace that drawn out.

BORED WELLS

Bored wells are made with earth augers turned and lifted by hand or horse power. The method is not extensively used and is confined to relatively small diameters and depths and to clay, sand, fine gravel, or other comparatively soft materials free from boulders.

DRIVEN WELLS

Driven wells are iron or steel pipes forced into a water-bearing bed. They are more likely to yield hard water than are shallower dug wells, but they are less likely to receive organic impurities.⁴ In simplest form, 1 to 3-inch extra strong wrought pipe is cut in convenient lengths and provided with a well point driven as shown in Figure 16, *A*. The pipe joints should be coated with red lead or graphite and oil and should be tightly screwed with pipe wrenches or tongs. Otherwise, if used as suction pipe, it will leak air, or when the pipe is being driven the threads may be stripped or the couplings split. The top must have a heavy cap or steel drive-head to prevent battering the pipe. A 1½-inch well need not cost over 50 cents per foot, including extra strong pipe. The method is very useful in prospecting for water within 20 or 30 feet of the surface and for temporary supplies. Where there is no rock it is the quickest and cheapest method of obtaining ground water. The principal fault of such wells lies in the strainer becoming corroded and choked. Often a well must be abandoned in a few years or the pipe pulled and redriven.

Open-end, driven wells are less easily choked, and if properly cleared of clay and silt, are frequently used in very fine sands. The material which enters the drive pipe is removed with a sand pump or is washed up with the aid of a force pump and a smaller pipe known as the drill or wash pipe inside the drive pipe. A steel jetting drill is screwed into the end of the wash pipe and is very useful to loosen the earth and split small stones at the bottom of the drive pipe, which should be protected by a steel coupling or shoe. Use of a saw-tooth shoe and turning the entire string of pipe at each blow increases the progress. To facilitate water entering the well the first piece of pipe usually has numerous one-fourth-inch holes drilled through the shell. Figures 16, *B*, *C*, and *D*, show hand outfits and

⁴ Out of 1,943 wells less than 25 feet deep in Illinois, 74 per cent were condemned; out of 2,707 wells 25 to 50 feet deep, 63 per cent were condemned; out of 1,333 wells 50 to 100 feet deep, 32 per cent were condemned; out of 3,228 wells more than 100 feet deep, only 13 per cent were condemned. See Water Survey Series, No. 13, Edward Bartow, director, State Water Survey, Urbana, Ill., p. 15.

methods for driving open-end wells. Figure 16, *D* shows the jetting process; the method is equally useful with the driving outfits shown in Figure 16, *B* and *C*. Wells always should be tested for yield when the wash water fails to rise to the surface of the ground. Where the



FIG. 16.—Hand methods of driving wells. *A*, use of a heavy striking hammer, sledge, or maul; *B*, drive block with hole through center and raised by direct lift; laborers prefer this method, and their weight assists the driving; *C*, drive block raised with the aid of a pulley, and its fall guided by a spindle which goes inside the pipe; *D*, jetting process.

material is coarse enough to “lose” the wash water, it is of suitable character to yield freely.

Driving and jetting outfits can often be made from odds and ends about the farm. They are readily operated by three or four men to depths of 100 or more feet in clays, sands, and gravels. Frequently an outfit with one experienced well-driver may be hired for

\$8 or \$10 a day, and with the aid of farm hands, after everything is assembled, a well may be sunk 50 feet in a day. Fair prices for 2 and 2½-inch wells are \$1 to \$2 per foot, including extra strong pipe. Where the water is very deep, driven wells are usually 4 to 8 inches in diameter and are sunk by parties experienced in the work.

CLEARING DRIVEN WELLS

A success or failure with driven wells often is a matter of freeing them of fine material. Water may be within 20 or 30 feet of the surface, but the pump handle yanks back quickly, indicating that the material is too tight to yield freely. Such wells must be coaxed. The pump should be worked slowly and patiently to draw out the fine material and create percolation into the well. Should the well choke from inflow of fine material the pump should be detached and the material should be bailed or washed out. As more clay, silt, and fine sand are brought out of the well the pumping may become more rapid. The result often is the creation of a pocket of coarse material about the bottom of the pipe, giving a free-yielding well.

There are several methods of coping with quicksand in tubular wells. If there is probability of coarse material beneath the quick sand the latter may be kept out by driving the casing through it. Sometimes quicksand is restrained by forcing to the bottom a large sponge or several small sponges wired together and weighted with small stones. Sometimes a brass strainer, closed at the bottom and about one-fourth of an inch less in diameter than the bore of the well and of a length to extend through the fine sand, is lowered to the bottom of the well. The casing is pulled up till its bottom is nearly flush with the top of the strainer. A tapered brass tube to the top of which is attached a lead packer is inserted at the joint. A swedge block or expander is lowered till it rests on the lead packer. A few blows suffice to expand the lead outward against the casing making a sand-proof joint between the strainer and casing.

Sometimes a strainer 4 to 6 inches smaller than the casing is employed. It is lowered from the surface by means of ordinary screw pipe cut in lengths convenient for handling. The strainer is provided with guides to center it in the bottom of the well, and coarse sand or fine gravel a little larger than the strainer openings is poured in at the top to fill the annular space between the strainer and casing. The sand filling may be brought to the surface of the ground and the whole outer casing drawn, leaving the pipe with which the strainer was lowered as the permanent casing. If it is desired to retain the original casing, the sand filling may end above the quicksand. The casing is drawn up until its bottom is above the quicksand. The pipe used to lower the strainer is unscrewed from the strainer and is removed from the well. Such portion of the casing as is above ground is cut off.

DRILLED WELLS

A drilling outfit is necessary where there is rock. A gasoline or steam drilling machine is generally used, and wells are put down by contract with persons equipped for the business. Recent contract

prices for 6 to 8 inch cased wells vary from \$3 to \$5 per foot. The yield of drilled wells is sometimes increased by shattering the rock with dynamite. This is called "shooting" or "torpedoing" a well and may create openings to adjacent passageways carrying water. The method is less used than formerly, and in all instances, because of uncertain results and liability of damage to the well or loss of the existing supply, it should be employed only as a last resort.

FLOWING WELLS

Figure 13, *E* shows three flowing wells side by side on a Utah farm. Shallow flowing wells are usually short-lived. Artesian flows derived from strata outcropping in distant elevated localities frequently remain strong for many years. In general, however, there is a marked tendency toward exhaustion because of reduced pressure and the sinking of other wells tapping the same stratum. By using sound, heavy casing and valves to regulate the flow as needed, and by capping or plugging abandoned wells, farmers can aid greatly in conserving artesian supplies.

HYDRAULIC RAMS

Hydraulic rams are not mechanical toys. They are the most economical pumps known and have been used to raise large quantities of water. Two farm rams are shown in Figures 13, *C* and *D*.

Hydraulic rams utilize the principle of water hammer. Their operation will be understood from Figure 17 and the following description: Water flows from the source of supply through a straight iron pipe *D*, wasting through escape valve *E* until the velocity is sufficient to force the valve outward to its seat. This creates a "kick" or water hammer in pipe *D* and opens check valve *C*, through which some of the flow is forced into air chamber *A* and delivery pipe *B*. The greater pressure in pipe *B* quickly overcomes the movement and causes a reaction or backward pulsation closing valve *C* and unseating valve *E*, whereupon the water in pipe *D* flows again and the whole operation is repeated. On the recoil, a little air is sucked through the sniff valve *S* to maintain the supply in chamber *A*.

The approximate quantity of water raised by a good ram, properly installed, may be estimated from Table 3.

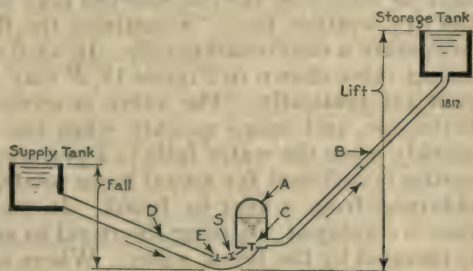


FIG. 17.—General layout of a hydraulic ram installation. *D*, Drive or supply pipe; *E*, escape valve; *C*, check valve; *A*, air chamber; *B*, delivery or discharge pipe; *S*, sniff or air valve

TABLE 3.—Quantity of water raised by a hydraulic ram

Lift (feet) divided by fall (feet)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	20
Gallons raised in 24 hours for each gallon per minute to the ram	605	370	260	195	150	120	100	85	70	60	50	45	40	35	22	16

Example: What quantity of water will be raised in 24 hours to a height of 48 feet above a ram receiving 3 gallons per minute from a

spring 12 feet above the ram? Solution: Lift (48) divided by fall (12) equals 4; under 4 in Table 3, 1 gallon per minute to the ram raises 260 gallons in 24 hours; therefore 260 multiplied by 3 equals 780 gallons, the quantity of water that will be raised by the ram. If the delivery pipe is very long, the friction loss therein should be determined from Table 4 on page 23 and should be added to the lift (48 feet in the above example) to find the true pumping head.

Manufacturers of rams require the following information to determine the size needed for a particular installation: (1) Quantity of water in gallons per minute available at ram; (2) quantity of water in gallons per day desired at buildings; (3) available fall in feet; (4) horizontal distance in feet in which fall occurs; (5) length of delivery pipe in feet; (6) lift in feet. Manufacturer's instructions for installing should be closely followed, thereby fixing responsibility for results.

The minimum or the average flow should govern the size of the ram, as otherwise the one selected may be too large to be actuated by the dry-weather flow. Sometimes the flow of a spring is too small to operate a ram continuously. In such cases a float-controlled regulating valve shown in Figure 13, *F* may be used to stop and start the ram automatically. The valve is screwed on the upper end of the drivepipe, and opens quickly when the supply tank fills and closes quickly when the water falls to a permissible level. Sometimes a small spring is sufficient for actual home needs, but the power head must be obtained from a near-by brook. In such instances a double-acting ram is employed, utilizing the recoil to admit the spring water which is pumped by the brook water. Where the power supply is far from the ram, it is usual to pipe the flow to an open tank or standpipe located so as to secure the desired length and fall of drivepipe.

A hydraulic ram should be fastened to a suitable foundation and housed properly. The waste pipe from the ram pit should be of good size and not subject to backwater or other obstruction. Four-inch drain tile is often used. The drivepipe must be air-tight. Bends are a detriment, but if unavoidable should be of gentle curvature, leaving the bore unrestricted. For small installations, lead pipe is much better than iron. Full-way gate valves should be used to lessen friction. The upper end of the drivepipe, which may be made bell-shaped to facilitate entry of water, should be submerged at least a foot to prevent sucking air, and should have a strainer with openings totaling three to five times the cross-sectional area of the pipe. Rubber valves are less noisy than metal, but where the pounding is objectionable, as it may be in a dwelling, a piece of lead pipe or rubber hose inserted in the delivery pipe lessens or ends the trouble.

Every newly installed ram requires adjustment. Action may be induced by intermittently pressing down on the waste valve and allowing it to rise with the escape of water. The travel of the escape valve and the rapidity of its strokes should be regulated by experiment (by sight, sound, and inference). To illustrate: A ram running 37 strokes a minute used 13.1 gallons, of which 10.1 gallons were wasted and 3 gallons were pumped. When speeded to 72 strokes a minute the ram used only 4 gallons, of which 2.9 gallons were wasted and 1.1 gallons were pumped. If the escape valve remains up, excessive pressure or leakage in the ram is indicated. If the escape valve remains down, lack of fall or water is indicated. This difficulty can

often be overcome partially by plugging two (one on each side) or more of the small holes in the plunger. Should the ram operate and discharge no water, lack of air in the air chamber or a leak in the delivery pipe is probable.

FRICTION LOSS AND PUMPING HEAD

Movement of water in a pipe produces friction, a form of resistance that increases with the length and roughness of the pipe and the rapidity with which the water moves. Wherever much water is to be delivered through a long pipe, the power or head necessary to overcome friction should be determined. This is called friction loss or friction head. Its effect is to increase the vertical height against which a pump operates. Bends, especially sharp turns, in a pipe line also increase the friction, but ordinarily the farmer may neglect this loss in discharge pipes. Excessive loss due to friction may be avoided by increasing the size of the pipe. Table 4⁵ shows the friction head (number of feet to be added to the vertical height) for each 100 feet of iron pipe (not new) to overcome friction when discharging given quantities of water. The comparative discharging power of pipes of the several sizes also is shown.

TABLE 4.—Friction head or loss and comparative discharging power of pipes

Discharge in gallons per minute	Diameter of pipe in inches												
	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4	5	6
	Friction loss in feet for each 100 feet length of pipe												
0.5	7.8												
1	28.0	6.4	2.1										
2	103.0	23.3	7.4	1.9									
3		49.0	15.8	4.1	1.26								
4			27.0	7.0	2.14	0.57	0.26						
5			41.0	10.5	3.25	.84	.40						
6				14.7	4.55	1.20	.56	0.20					
8				25.0	7.8	2.03	.95	.33	0.11				
10				38.0	11.7	3.05	1.43	.50	.17				
12					16.4	4.3	2.01	.70	.24				
14					22.0	5.7	2.68	.94	.32				
16					28.0	7.3	3.41	1.20	.41				
18						9.1	4.24	1.49	.50				
20						11.1	5.2	1.82	.61	0.25			
25						16.6	7.8	2.73	.92	.38	0.09		
30						23.5	11.0	3.84	1.29	.54	.13		
35							14.7	5.1	1.72	.71	.17		
40							18.8	6.6	2.20	.91	.22		
45							23.2	8.2	2.76	1.15	.28		
50								9.9	3.32	1.38	.34	0.11	
60								13.9	4.65	1.92	.47	.16	
70								18.4	6.2	2.57	.63	.21	
80								23.7	7.9	3.28	.81	.27	
90									9.8	4.08	1.00	.34	
100									12.0	4.96	1.22	.41	
120									16.8	7.0	1.71	.58	0.24
140									22.3	9.2	2.28	.76	.32
160										11.6	2.91	.98	.40
180										14.8	3.61	1.22	.50
200										17.8	4.4	1.48	.61
240										25.1	6.2	2.08	.86
Comparative dis- charging power of pipes ¹	.03	.08	.16	.47	1.0	1.8	2.9	6.2	11.1	18.0	38.3	68.9	111.3

¹ Based on diameters raised to the 2.63 power. Discharge depends not only upon size of pipe but upon velocity of flow, a factor that changes with the relation of head of water to length of pipe. Inspection shows that doubling the diameter of a pipe increases the discharging power about 6 times, assuming like heads of water and like lengths of pipe. Assuming like velocities, doubling the diameter increases the capacity 4 times, because the areas of circles are proportional to the squares of their diameters. This table should not be used for pipes shorter than 500 times the interior diameter.

⁵ Hydraulic Tables, Williams and Hazen, N. Y., 1906. Coefficient here used is 100, a fair value where the interior of iron pipe is roughened by 10 to 15 years' rust formation.

A column of water 1 foot high and having a base equal in area to 1 square inch weighs 0.43 pound. The pressure on the base is equal to the weight of the column. Double the height, and the weight and the pressure are doubled. Hence it may be taken for granted that the pressure of water at rest (static pressure or head) is in direct proportion to the vertical height or depth of the water. From the above Table 5 is computed.

TABLE 5.—Vertical height in feet and equivalent pressure in pounds per square inch

Height	Pressure	Height	Pressure	Height	Pressure
<i>Feet</i>	<i>Pounds</i>	<i>Feet</i>	<i>Pounds</i>	<i>Feet</i>	<i>Pounds</i>
1	0.43	20	8.67	75	32.51
2	.87	25	10.84	80	34.68
3	1.30	30	13.00	85	36.85
4	1.73	35	15.17	90	39.01
5	2.17	40	17.34	95	41.18
6	2.60	45	19.51	100	43.35
7	3.03	50	21.67	110	47.68
8	3.47	55	23.84	120	52.02
9	3.90	60	26.01	130	56.36
10	4.33	65	28.18	140	60.69
15	6.50	70	30.35	150	65.03

Two examples are given to show the use of Tables 4 and 5. Example 1: How much water will be delivered by 500 feet of 1½-inch pipe from a spring 26 feet above the outlet? Solution: Multiply the head (26) by 100 and divide the product (2,600) by the length (500), giving 5.2. In Table 4 under 1½-inch pipe find 5.2 and follow to the extreme left to find the answer—20 gallons per minute. It is assumed that all the head is used to overcome friction and that the water emerges full bore of the pipe. Example 2: What is the pumping head where a pump is delivering 3 gallons a minute through 1,000 feet of 1-inch pipe to a hydropneumatic tank carrying 39 pounds per square inch situated 20 feet higher than the pump? Solution: To the vertical height water is raised (20 feet) must be added friction loss which is 1.26 feet for each 100 feet of length, or 12.6 feet; there must be added the equivalent height of the 39-pound tank pressure which from Table 5 is seen to be 90 feet; 20 plus 12.6 plus 90 equals 122.6 feet, the true pumping head.

PUMPS

If a perfect vacuum could be created in a pump cylinder at sea level, water would follow the plunger to a vertical height of 33.9 feet. This is called suction or suction lift. With elevation above sea level, air becomes lighter and suction becomes weaker. It will be helpful to see how the discharge of a pump diminishes as the suction lift increases. Figure 18 shows the results of a test close to sea level with an ordinary 1¼-inch pitcher pump. The diagram shows the discharge decreasing from 10.3 gallons per minute when the suction lift is low, to no discharge at 30 feet 2 inches, the extreme height to which the pump would draw. It is important to have a low suction lift but approximately three-fourths as much water was drawn when the lift was 22 feet as when it was 1 foot. On this

basis Table 6 gives the limiting suction lift for the satisfactory operation of pumps at stated elevations up to 8,000 above sea level.

TABLE 6.—*Limiting suction lift of pumps (vertical distance from water level to top of cylinder)*

Elevation above sea level	Atmospheric pressure reduced to equivalent head of water	Limiting suction lift ¹	Elevation above sea level	Atmospheric pressure reduced to equivalent head of water	Limiting suction lift ¹
	<i>Feet</i>	<i>Feet</i>		<i>Feet</i>	<i>Feet</i>
Sea level.....	33.9	22.0	5,000 feet.....	28.0	18.2
1,000 feet.....	32.6	21.2	6,000 feet.....	27.0	17.5
2,000 feet.....	31.4	20.4	7,000 feet.....	26.0	16.9
3,000 feet.....	30.2	19.6	8,000 feet.....	25.0	16.2
4,000 feet.....	29.1	18.9			

¹ Taken as 65 per cent of the heads shown in the second column.

Suction pipes may be long provided the friction loss (see Table 4) plus the vertical height from water level to pump valve does not exceed the limiting suction lifts shown in Table 6. Lengths of 100 to 1,000 feet are frequent. An ordinary pitcher pump raised 5 gallons per minute through 320 feet of 1¼-inch pipe having two elbows, a foot valve, and a vertical height approximating 19 feet. Suction pipes should be straight, air-tight, slope uniformly upward from well to pump, and never be smaller than the pump suction connection. Long suctions should be larger than such connection and should have a foot valve and strainer on the end in the well.

Pumps may be divided into two classes—suction and force, or a combination of these types. A suction pump has the cylinder above the water; it does not raise water above the pump nor discharge it against pressure. A force pump can raise water above itself and against pressure. The general arrangement of valves in these two types of pump and in a deep-well pump is shown in Figure 19.

Where a pump is more than 22 feet above the water it is necessary to lower the cylinder. Where the water is 22 to 30 feet below the surface, a set-length pump may be used. This pump has the pipe and rod lengthened to permit placing the cylinder several feet below the well platform. A drip hole may be drilled in the pipe just above the cylinder, thus allowing the water above to escape and, provided the platform is tight, preventing freez-

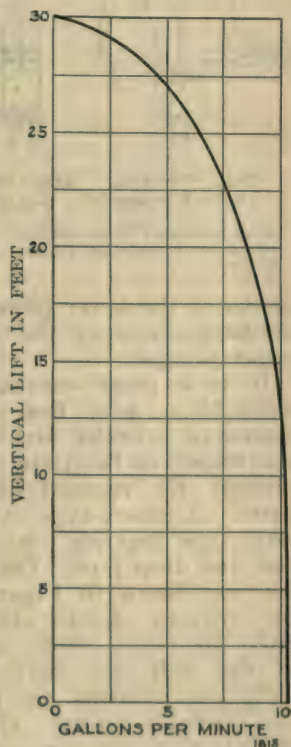


FIG. 18.—Diagram showing how the discharge of a pump varies with the suction lift

ing. By lengthening the pipe and rod and by using a small cylinder lowered into or near the water, this type of pump may be used in wells 75 or more feet in depth.

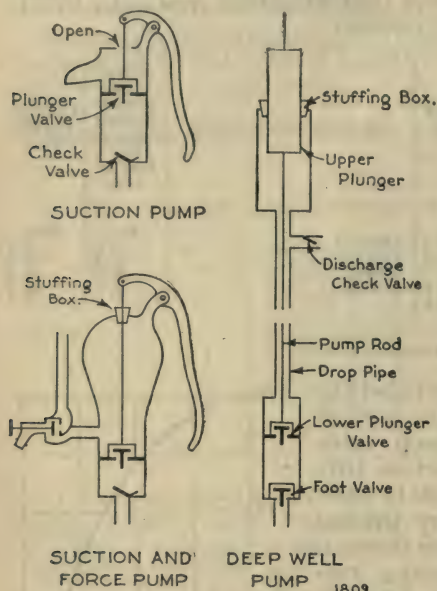


Fig. 19.—General arrangement of valves and plungers in suction, force, and deep-well pumps

stroke of the lower plunger is forced to the discharge pipe by the down stroke of the upper plunger.

It is a great convenience, especially in wells 75 or more feet in depth, to use an open-type cylinder fitted for drop pipe one size larger, to facilitate pulling up the lower plunger for renewal of leathers or other parts. A closed-type cylinder with smaller drop pipe requires drawing cylinder, pump rod, and drop pipe. The two types of cylinder are shown in Figure 20. The size of the cylinder should always be determined from the size, depth, and yielding power of the well, the hours within which the daily requirements are to be pumped, and the available power. Ordinarily the day's pumping is done in one to three hours. Deep wells and hand and windmill outfits take the smaller cylinders; the advice of a reliable dealer or manufacturer whose product is to be used should always be obtained. Table 7 shows the capacity of pumps per stroke for one single-acting cylinder.

Where the water is far below suction lift, a deep-well pump driven by power is generally used. The working head is placed over the well, and pump rod and drop pipe are lengthened to permit setting the lower cylinder in or close to the water. Submergence is best because it keeps the cylinder primed and the pump leathers pliable. Deep-well pumps are usually single acting; that is, water is lifted on the up stroke. This brings a heavy, variable load on the working parts, and an upper or differential cylinder in or just below the working head is employed to divide the work between the up and down strokes. In this way the water that is lifted to the surface by the up

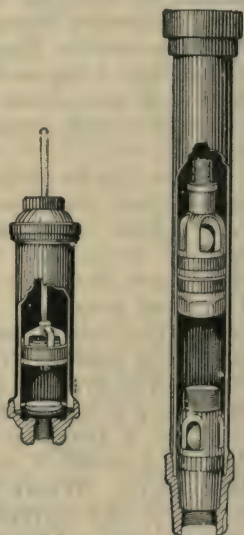


Fig. 20.—Closed and open cylinders

TABLE 7.—Capacity of pumps¹

Diameter of cylinder in inches	Length of stroke in inches								
	2	3	4	5	6	7	8	10	12
	Capacity per stroke in gallons								
1.....	0.007	0.010	0.014	0.017	0.020	0.024	0.027	0.034	0.041
1½.....	.011	.016	.021	.027	.032	.037	.042	.053	.064
1¾.....	.015	.023	.031	.038	.046	.054	.061	.077	.092
2.....	.021	.031	.042	.052	.062	.073	.083	.104	.125
2½.....	.027	.041	.054	.068	.082	.095	.109	.136	.163
2¾.....	.034	.052	.069	.086	.103	.120	.138	.172	.207
3.....	.042	.064	.085	.106	.127	.149	.170	.212	.255
3½.....	.051	.077	.103	.128	.154	.180	.206	.257	.308
3¾.....	.061	.092	.122	.153	.184	.214	.245	.306	.367
4.....	.072	.108	.144	.179	.216	.251	.287	.359	.431
4½.....	.083	.125	.167	.208	.250	.291	.333	.416	.500
4¾.....	.096	.143	.191	.239	.287	.335	.383	.478	.574
5.....	.109	.163	.218	.272	.326	.381	.435	.544	.653
5½.....	.138	.206	.275	.344	.413	.482	.551	.688	.826
6.....	.170	.255	.340	.425	.510	.595	.680	.850	1.020
6½.....	.206	.308	.411	.514	.617	.720	.823	1.028	1.234
7.....	.245	.367	.490	.612	.734	.857	.979	1.224	1.469

¹ Plunger displacement. No allowance for slip of water past valves. For double-acting cylinders multiply by two. For a longer stroke than shown in the table add the capacities of two shorter strokes to make the required length of stroke.

Figure 21 shows pumps of the kinds described. In selecting a pump the following information should be known: (1) The kind of well, inside diameter, depth to bottom, depth cased, depth to water level both at rest and when pumping, and the sustained yield, as found by test, in gallons per minute (see "Ground Water Supplies," page 12, and "Wells," page 14); (2) the maximum quantity of water required at buildings, gallons per hour or day; (3) distance from well to proposed location of pump and the vertical height between these points; (4) distance from pump to reservoir or tank, and the vertical height between these points; (5) kind of power.

If electricity is to be used the following information should be obtained from the local light or power company: The voltage, if the current is direct, the voltage, cycles, and phase, if the current is alternating. With the above information a reliable manufacturer or dealer will be able to select suitable equipment and the farmer can check the suitability of the selection.

PUMPING WITH COMPRESSED AIR

AIR LIFTS

Air lifts are useful in raising large quantities of water from deep wells. Compressed air is led through a small pipe deep into a well, and is there released in an upward direction through numerous small holes in the side of a nozzle-shaped foot piece to which is screwed a vertical pipe for the delivery of water to the surface. The air, as small jets or bubbles in contact with water, rises and expands within the delivery pipe, carrying with it and ejecting some of the water. To secure the best results, the submergence and the size and arrangement of air and water pipes for each installation should be determined by the manufacturer or others experienced in the work. Air lifts have no moving parts in the well. The main advantages are simplicity, durability, large capacity, noninterference by cold,

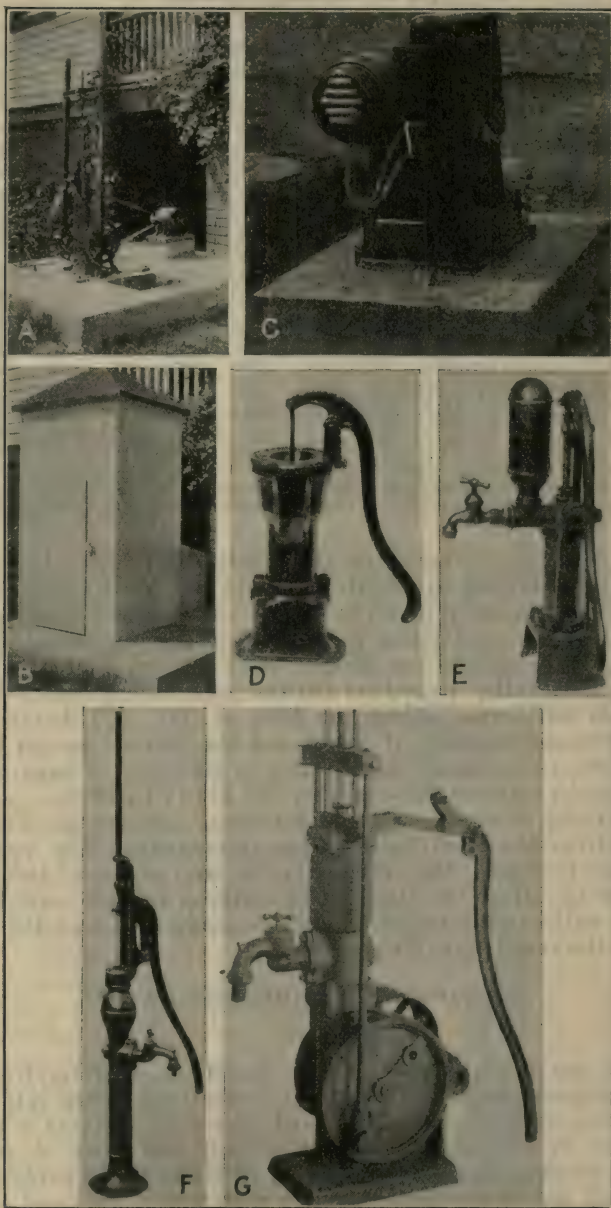


FIG. 21.—Pumps. *A*, Pumping jack and force pump with underground and spout discharge controlled by hand wheel; *B*, after completion of improvements; *C*, pumping unit consisting of deep-well pump, underground discharge, electric motor with a worm-gear drive inclosed in a weatherproof housing; *D*, pitcher spout pump; *E*, house force pump; *F*, hand and windmill force pump with front and back outlets; *G*, power working head for shallow or deep wells, front and back outlets, belt drive adjustable stroke

grit or sand, and adaptability to drawing from a crooked well or from several widely-separated wells with one power outfit. Disadvantages are cost, low efficiency unless correctly designed and installed, and tendency of the air to slip over the water where the horizontal discharge distance is great. An air lift is often used to raise water to the surface, after which it is pumped by other means.

AIR-DISPLACEMENT PUMPS

An air-displacement pump consists of a submerged cylinder or cylinders from which water is automatically displaced by compressed air, the operation of the pump being wholly controlled by opening and closing any faucet on the water-delivery pipe. No water is stored, and the pump is at rest when faucets are closed. The chief advantage of the system is that water may be taken from one or several sources with one power outfit and delivered direct from well to faucet. The system is not cheap and is not as simple as some other methods of raising water. Pipes and pumps must be tight and remain tight in service and the working parts be maintained in good order.

Air lifts and air-displacement pumps require some method of compressing and storing air. Figure 22, *E*, shows these parts in a typical air-displacement pump installation; they consist of a gasoline engine, air compressor, air tank, and air pipe to the well in the foreground, and water pipe from the well. The air-displacement pump is submerged in the well; if desired, an air-lift foot piece could be employed.

POWER

The theoretical horsepower necessary to raise water is found by multiplying the gallons pumped in one minute by the total lift in feet, including friction in both suction and discharge pipes, and dividing the product by 4,000. To overcome losses in the machinery the theoretical horsepower is generally multiplied by 3 to 4 for electric-driven pumps and by 4 to 6 for pumps driven by gasoline engine. Ordinarily half-horsepower motors and 1-horsepower engines are sufficient for farm pumping, but it is safest to compute the amount of power needed and to get the advice of a reliable pump concern. Table 8 shows the actual horsepower required to pump water, assuming an overall efficiency of 25 per cent (actual four times the theoretical).

TABLE 8.—Horsepower required to pump water (based on overall efficiency of 25 per cent)

Gallons per minute	Lift in feet									
	50	60	70	80	90	100	125	150	175	200
	Horsepower required									
2	0.10	0.12	0.14	0.16	0.18	0.20	0.25	0.30	0.35	0.40
3	.15	.18	.21	.24	.27	.30	.39	.45	.53	.60
4	.20	.24	.28	.32	.36	.40	.50	.60	.70	.80
5	.25	.30	.35	.40	.45	.50	.63	.75	.88	1.00
6	.30	.36	.42	.48	.54	.60	.75	.90	1.05	1.20
7	.35	.42	.49	.56	.63	.70	.88	1.05	1.23	1.40
8	.40	.48	.56	.64	.72	.80	1.00	1.20	1.40	1.60
9	.45	.54	.63	.72	.81	.90	1.13	1.35	1.58	1.80
10	.50	.60	.70	.80	.90	1.00	1.25	1.50	1.75	2.00

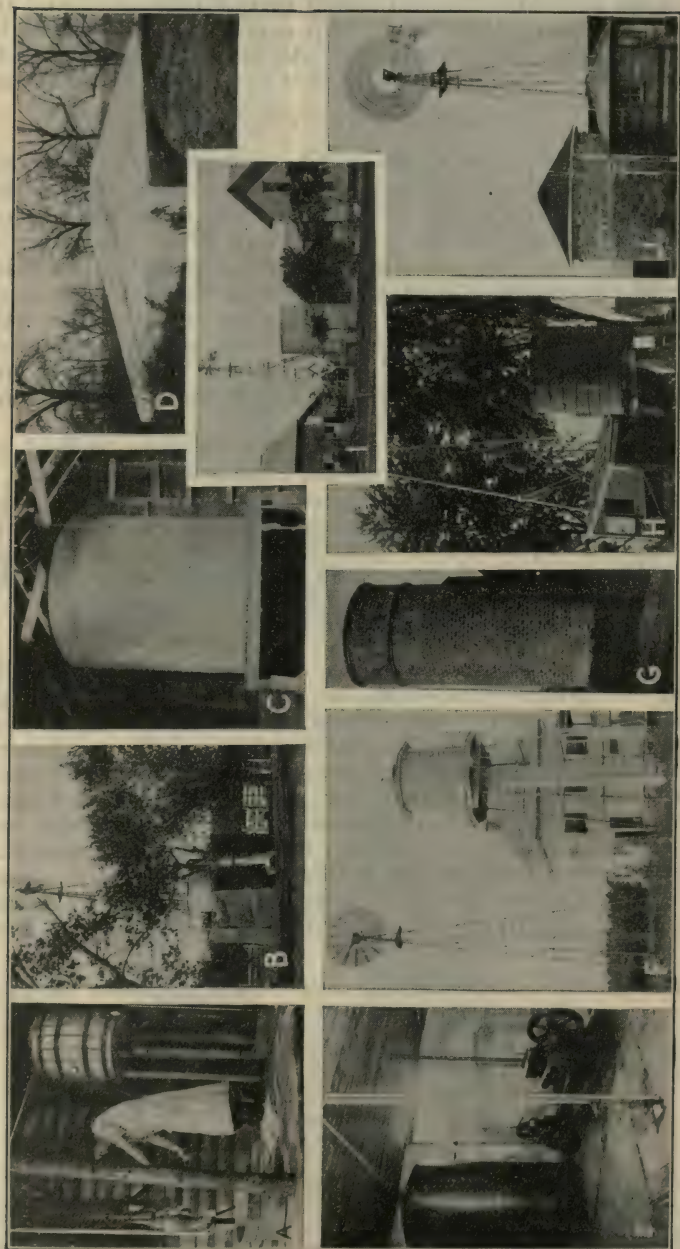


FIG. 22.—Pumping and storing water. *A*, Pumping to a wood barrel, faucet in the kitchen; *B*, galvanized steel tank protected by straw; *C*, galvanized tank in barn loft; note the bulge caused by ice near the top; *D*, square concrete, underground tank; *E*, pumping with compressed air; *F*, a serviceable installation; *G*, water tank on top of a clay tile silo; *H*, wood tank 8 by 8 feet; supply pipe wrapped with burlap and enclosed in a wood box packed with cinders; *I*, concrete standpipe; *J*, attractive rubble masonry tank

Hand power is unsuited to large supplies or high lifts. Windmills are more extensively used for pumping water than any other source of power, and if well installed and maintained give good low-cost service. In selecting an outfit, the prevailing wind velocity, the size of the wheel, the diameter of the cylinder, and the lift should be considered to avoid overloading. Windmills are generally loaded in the Middle West to operate in 15-mile winds, starting to pump in a 6 to 8-mile wind, doing excellent work in a 15-mile wind, and reaching the maximum in a 25 to 30-mile wind. In mountainous regions windmills are generally loaded for a 10-mile wind. With the exception of Kansas and a few other states the most desirable wind velocities for pumping rarely prevail as much as one-third of the time.⁶ The most common cause of overloading comes from using a cylinder excessively large in diameter. The longer periods of operation by small cylinders as compared to large cylinders, enables the former, in the course of a season or year, to pump more water. Cylinders and mills which have long, slow strokes are recommended. Recommendations and claims as interpolated from the catalogues of different manufacturers of back-gearred windmills are given in Table 9.

TABLE 9.—*Approximate capacity of windmills (from manufacturers' ratings)*

Lift	Velocity of wind per hour	Diameter of wheel							
		6 feet		8 feet		10 feet		12 feet	
		Diameter of cylinder	Capacity per hour	Diameter of cylinder	Capacity per hour	Diameter of cylinder	Capacity per hour	Diameter of cylinder	Capacity per hour
<i>Feet</i>	<i>Miles</i>	<i>Inches</i>	<i>Gallons</i>	<i>Inches</i>	<i>Gallons</i>	<i>Inches</i>	<i>Gallons</i>	<i>Inches</i>	<i>Gallons</i>
25	10	2½	140	3½	320	4¼	420	5½	1,010
25	10	2	120	3	270	4	360	5	675
50	10	1¾	110	2¾	180	3½	305	4	520
75	10			2½	135	3	235	3	365
100	10			2	105	2½	160	2¾	265
125	10			1¾	90	2	125	2½	200
25	15	3½	250	5	590	7	1,190	9	2,190
35	15	3	175	4	400	6	880	7	1,595
50	15	2½	125	3½	280	5	610	6	1,165
75	15	2	85	2¾	190	4	375	5	700
100	15	1¾	60	2½	140	3½	305	4½	505
125	15			2¾	115	3¼	250	3¾	450

Gasoline and oil engines are well adapted to farm pumping and may be equipped to stop at any desired pressure in the tank supply. Hot-air engines have had considerable use. The use of electricity for pumping is increasing rapidly. The method is clean, quiet, and convenient, and stopping and starting a distant pump by throwing a switch may be a reality wherever transmission lines are so near as to make this power available. Electric motors may be had in small sizes and low powers and may be arranged to start and stop automatically with changes in the tank pressure; two installations are shown in Figures 21 *C* and 25 *C*.

⁶ Information on the velocity and prevalence of wind may be obtained from the U. S. Weather Bureau, Washington, D. C.

STORAGE OF WATER

ELEVATED TANKS

Water may be stored in wood, steel, or masonry tanks, and to secure gravity delivery the tank must be elevated above all faucets. Tanks placed in attics, barn lofts, and upon light trestles are unsatisfactory. The objections relate to insecurity and leakage, lack of pressure, and unwholesomeness in summer and freezing in winter. Masonry tanks may be placed on a hill, silo, or masonry tower. Where possible, an underground concrete tank on a hill is very desirable, avoiding trouble with frost and giving a tempered and sure supply. Tanks should hold more than one day's supply. For wind-

mill supplies the requirements of a week or more may be needed at times. Tanks should be provided with a waste pipe and valve to facilitate emptying and cleaning, and without fail should be covered tightly for protection against heat, cold, dust, vermin, and sunlight. Where exposed to light, ground and filtered waters are liable to develop growths which impart objectionable odor, taste, or appearance. Figures 22, 23, and 24 show a number of poor and good tanks.

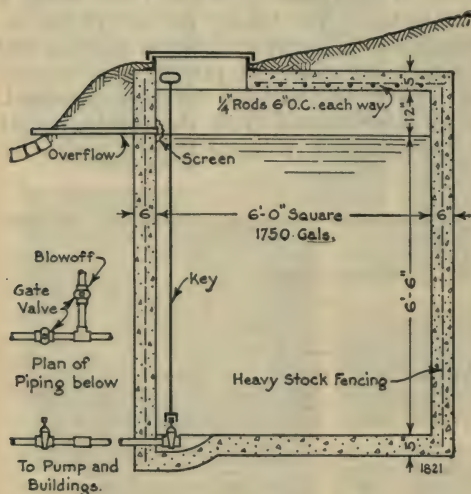


FIG. 23.—Working drawing for a square, reinforced concrete, underground tank. Very convenient when emptying and cleaning a tank, to have a valve on the supply pipe and a valve on a branch pipe or blow-off ending above ground and graded to drain the higher situated pipe and tank; closing the main valve and opening the branch valve empties the tank

HYDROPNEUMATIC TANKS

Water may be stored and delivered to the faucet by the use of a hydropneumatic (water-air) tank. The tank need not be elevated and usually is conveniently located in a utility room, basement, or cellar. Hydropneumatic tanks must be absolutely air-tight. Air being lighter than water occupies the upper portion of the tank, and it presses with increasing force against the water as either more water or more air is pumped into the tank. When air and water are under pressure the latter gradually absorbs the former, and this absorption is the more rapid the higher the pressure. From time to time, therefore, the air supply must be replenished, or the tank becomes water-logged. Maintenance of the air supply is a vital factor. Inlet and outlet pipes must enter at the bottom of the tank. Hydropneumatic tanks are made of three-sixteenths inch or thicker steel with riveted and welded or calked joints. A range boiler or other thin-walled tank should not be used for this purpose. The smaller tanks generally are galvanized and may set vertically or horizon-

tally; the larger tanks are set horizontally. Figures 25 A and C show typical installations.

To obtain the best service from a hydropneumatic tank it is necessary to carry an initial or excess air pressure; that is, enough air to give pressure when no water is in the tank. Table 10 shows what percentage or fractional part of any tank, either vertically or horizontally set, contains water under varying conditions of gage pressure and initial air pressure.

TABLE 10.—Quantity of water in fractional part of total capacity of any hydropneumatic tank (based on atmospheric pressure of 14.7 pounds per square inch)

Gage pressure (lbs.)	Initial air pressure in pounds						Gage pressure (lbs.)	Initial air pressure in pounds					
	0	5	10	15	20	25		0	5	10	15	20	25
5	0.25	-----	-----	-----	-----	-----	45	0.75	0.67	0.59	0.50	0.42	0.34
10	.40	0.20	-----	-----	-----	-----	50	.77	.70	.62	.54	.46	.39
15	.51	.34	0.17	-----	-----	-----	55	.79	.72	.65	.57	.50	.43
20	.58	.43	.29	0.14	-----	-----	60	.80	.74	.67	.60	.54	.47
25	.63	.50	.38	.25	0.13	-----	65	.82	.75	.69	.63	.56	.50
30	.67	.56	.45	.34	.22	0.11	70	.83	.77	.71	.65	.59	.53
35	.70	.60	.50	.40	.30	.20	75	.84	.78	.72	.67	.61	.56
40	.73	.64	.55	.46	.37	.27	80	.85	.79	.74	.69	.63	.58

Table 10 has many uses. It shows that if water is pumped into a tank having no pressure above that of the atmosphere until the gage shows 5 pounds, the tank will be one-fourth (0.25) filled with water; at 15 pounds it will be about one-half (0.51) full; at 30 pounds it will be two-thirds (0.67) full; at 45 pounds it will be three-fourths (0.75) full; at 60 pounds it will be four-fifths (0.80) full. An example will be helpful: Suppose a 220-gallon tank is half full of water under a gage pressure of 45 pounds and it is desired to know what quantity can be drawn before the pressure reaches 25 pounds. Inspection of Table 10 shows that if half (0.50) full at 45 pounds the initial air pressure must be 15 pounds, and under that excess a tank is one-fourth (0.25) full at 25 pounds gage pressure. Therefore, 0.50 minus 0.25 equals 0.25, which, multiplied by 220, equals 55 gallons, the available quantity. In general, the working capacity of a tank is from one-fourth to one-third of its total capacity.

PLANNING A SYSTEM

Sufficient information has been given to enable the farmer to outline his plans. An example will be helpful. Suppose a plant is desired to meet the needs of 5 persons, 25 cattle (including horses or mules), 50 sheep, and 50 hogs. The average daily requirements (see Table 1) would be as follows:

	Gallons
5 persons at 40 gallons each.....	200
25 cattle at 12 gallons each.....	300
50 sheep at 1 gallon each.....	50
50 hogs at 1 gallon each.....	50
Total.....	600

A suction pump would be used with a shallow supply (see Table 6); a deep-well pump or set-length pump would be used with a deep supply. A suction pump probably would be located in a dry, frost-proof basement, pump house, pit, or underground concrete chamber opening into the house cellar. A deep-well pump probably would be outside of main buildings: if in a pit or chamber, there

should be a manhole over the center of the well to permit pulling up the pump rod and drop pipe.

To do the day's pumping in two hours would require a pump having a capacity of 300 gallons per hour or 5 gallons per minute. The more constant the power, the more reliable the equipment, and the more accessible the repair parts the less is the need of large water storage. An automatic electric-driven pump (see fig. 25 *C*) may have a pressure tank varying in capacity from 10 gallons upward. It would be arranged to start pumping when the pressure falls to 25 or 30 pounds per square inch and to stop when the pressure reaches 45 or 50 pounds. With very small tanks any considerable use of water starts the pump and delivers water by direct pump pressure. The smaller pumps and tanks are especially useful for cistern and other household supplies, but the pump capacity (5-gallons per minute) figured

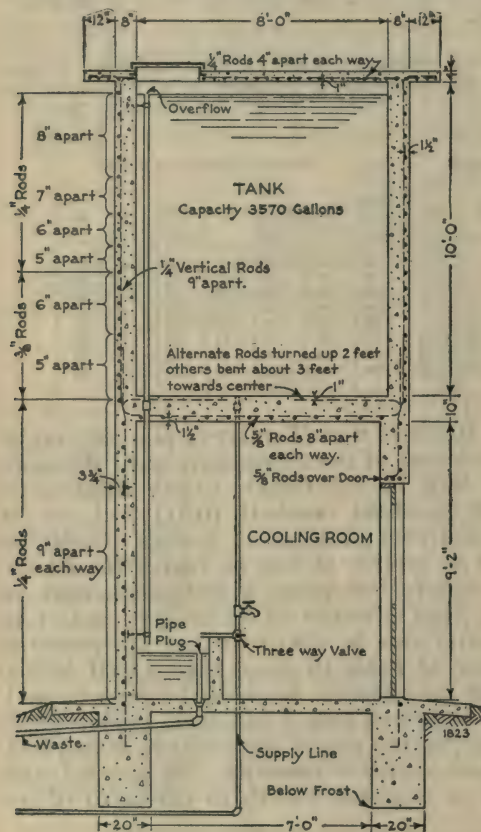


FIG. 24.—Working drawing for a combined cooling room and round reinforced concrete tank. Suggested mixtures for concrete: Tank walls and tank bottom 1:2:3 (1 volume cement, 2 volumes sand, 3 volumes stone, none larger than $\frac{3}{4}$ inch); cooling room walls 1:2:4; foundation 1:2½:5

in the example, would give fair discharge from one garden hose nozzle or two ordinary spray nozzles or two house faucets. Faster use of water would require a larger tank; a tank 30 inches in diameter by 6 feet long, 220 gallons capacity (water and air) should be sufficient for short heavy drafts, having a working capacity of approximately 50 gallons (oil barrel capacity) between the usual stopping and starting pressures noted above. If electric current cost 15 cents per kilowatt-hour the cost of pumping 600 gallons would approximate 14 cents per day.

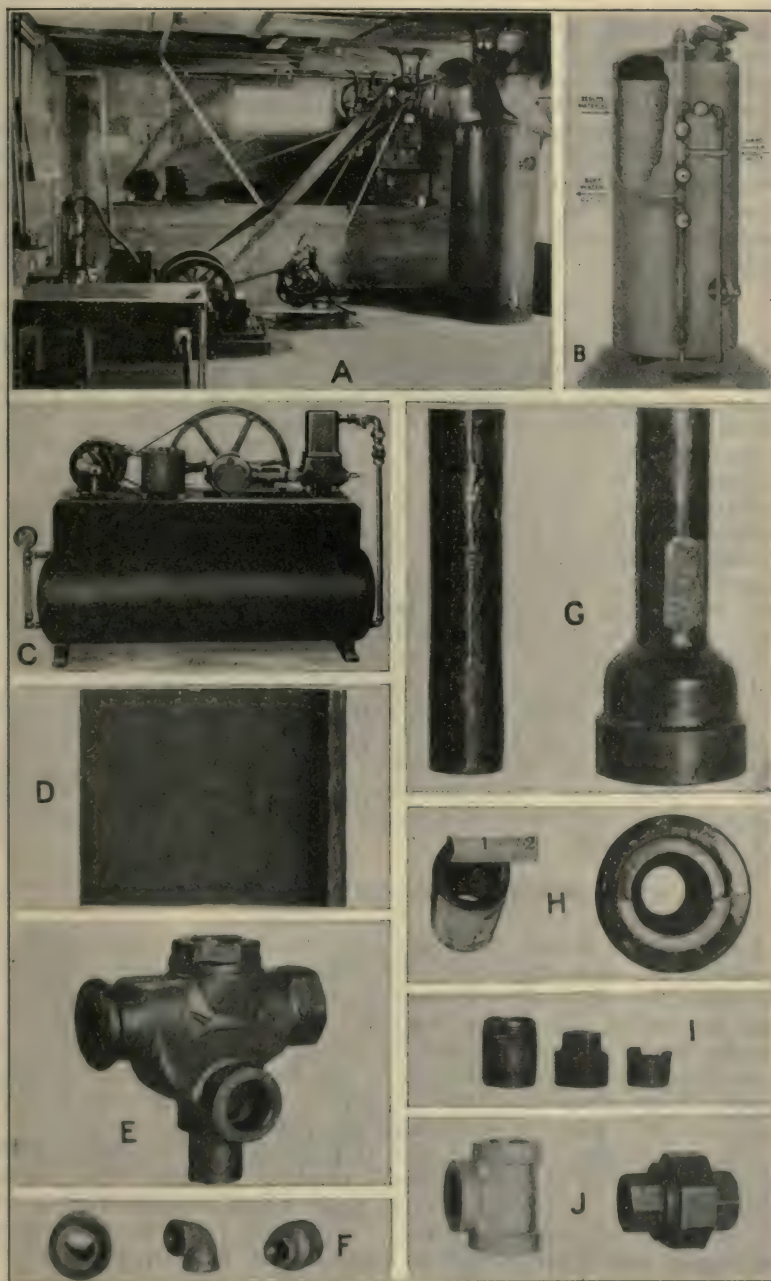


FIG. 25.—A, Hydropneumatic tank in basement; B, water softener—zeolites in a steel tank; C, automatic hydropneumatic tank system; D, bore of small, cast-iron water pipe after 35 years' use; E, a cold water valve for use on automatic systems; F, one-inch black wrought pipe lined with cement to a $\frac{3}{4}$ -inch bore; bore clear after 40 years in the ground; elbow; reducer; G, side view of short pieces of $1\frac{1}{4}$ -inch, hub and spigot, cast-iron pipe with foundry prepared lead joint ready for calking; H, end view of pipes shown in G; I, close nipple; plug; face bushing; J, tee; union

A larger tank would be used if the pump were not automatic or were engine-driven. Under those circumstances a hydropneumatic tank 42 inches in diameter and 14 feet long, 1,000 gallons total capacity would be suitable. With 20 pounds initial air pressure, it would deliver 290 gallons between pressures 45 and 25 pounds. (See Table 10: 0.42 minus 0.13 equals 0.29, which, multiplied by 1,000, equals 290 gallons.) Hence it would be necessary to operate the pump twice a day. If an elevated tank were to be employed its capacity should be larger, the equivalent of the tank shown in Figure 23 being suitable.

FIRE PREVENTION

Carelessness is the great fire hazard, and the watchword upon every farm should be prevention first and protection second. To fight a well-ignited fire successfully requires more water and higher pressure than ordinarily obtained with farm water systems. With 57 pounds pressure at the sillcock, 50 feet of three-fourths-inch rubber hose and an ordinary three-sixteenths-inch 75-cent nozzle, the discharge is $7\frac{1}{2}$ gallons per minute—less than three pailfuls. Such a stream directed at a large fire avails little, on account of its dispersion by heat, and it may happen easily that no water reaches the desired point. Other practical difficulties relate to frozen pipe lines, shortage or defects in the hose, misplaced nozzles, and lack of experience in the skillful use of the equipment when the time comes to fight fire. Although farm water systems are not generally given credit in insurance ratings, they may be of great value if a fire be discovered in its incipient stage, and it undoubtedly is wise, where a pressure system is installed, to provide a few well-placed hose connections. An automatic sprinkler system is very effective in preventing serious fire. Such an installation in costly farm buildings is a wise step, adding greatly to the value of the plant considered as a going business.

WATER SOFTENING AND IRON REMOVAL

An excess of certain mineral salts dissolved in water makes it hard, and therefore undesirable for drinking and cooking, ineffective and costly for cleaning and laundry purposes, and causes it to form scale in kettles, pipes, and boilers. Water may be softened for laundry and cleaning purposes by dosing it with ammonia, borax, or washing soda, all of which can be obtained at most grocery stores. Similar treatment is unsuitable for softening drinking water or large quantities of water for boiler and general farm purposes.

Water softening is the process of precipitating or changing the form of the dissolved minerals which produce hardness. The process further seeks to neutralize the free acids which cause corrosion. It is a chemical process and therefore is distinct from the removal of floating or settled solids such as mud or silt. Filtration alone does not soften water.

The principal hardening constituents are the carbonates, sulphates, and chlorides of lime and magnesia. The principal scale forming constituents are the carbonates and sulphates of lime and magnesia, and usually more or less solid matter such as mud or silt.

Hardness caused by lime and magnesia carbonates held in solution by carbonic acid may be partly removed by boiling the water which drives off the acid or by adding lime water or caustic lime which neutralizes the acid. Hardness caused by the sulphates of lime and magnesia is not removed by boiling but may be partly removed by adding soda-ash. Such water may be treated chemically to form a more or less insoluble precipitate which may be removed by sedimentation followed by filtration.

A group of impurities found in alkaline waters are sodium chloride (common salt), sodium sulphate (Glauber's salt), and sodium carbonate (soda ash). The first two constitute what is known as white alkali, and the third constitutes black alkali. These compounds are nonscale forming, but their presence in more than normal amounts makes water unfit for domestic consumption. The sodium salts are very soluble in water. They are not precipitated by heat or chemicals nor are they removed by filtration, but they may be removed by distillation.

Household water softeners are on the market. In every instance the water should be analyzed by a trained chemist to determine the proper treatment. The United States Department of Agriculture is unable to undertake the analysis or other examination of samples of water submitted by individuals, since its authority for work of this kind is restricted to official samples collected by the department. No doubt many of the states are similarly restricted with respect to analyses for individuals. However, those knowing of no private chemist who makes water analyses and who desire to employ one can usually obtain information regarding competent chemists who would be in a position to make these analyses by addressing the State health officer, the State chemist, the director of the agricultural experiment station, or the professor of chemistry in the State or other university. Many manufacturers of water softeners have laboratory facilities and do analytical work without charge to prospective customers. Not less than one-half gallon of water is required for an analysis. The water should be carefully collected in a clean bottle. The sample should be representative of the whole supply and should be packed with sawdust or similar material in a box or carton to prevent breakage or freezing.

Figure 25 *B* shows a water softener of the zeolite type suitable for home use and costing from \$175 upward, according to the size and make. The names and addresses of manufacturers can be obtained from trade and equipment directories, which can often be consulted in public libraries or commercial houses. Operation of this softener is not difficult or costly, common salt being the only chemical the householder uses to maintain it. Zeolites are hydrous aluminum sodium silicates, a hard granular mineral product insoluble in water and having the power to exchange its sodium for an equivalent amount of the calcium and magnesium in the hard water passing through it. The quantity of dissolved mineral matter in the water is not reduced, but its form is changed. The life of the zeolite material is maintained by adding at the top from time to time a 10 per cent solution of common table salt. The amount of salt and the frequency of applying it vary with the hardness of the water and the quantity of water used in the home. A report on one

installation states that 300 gallons of water are softened by one charging of 8 pounds of salt; another states that 600 pounds of salt a year softens 37,500 gallons of water.

Many waters, clear when drawn, contain dissolved iron which upon release of pressure and exposure to air settles out as a rusty-looking sediment. Such water is likely to cause rust spots on laundry work and is undesirable for other household purposes. Water of this kind can usually be improved by thorough aeration, followed by a period of rest to settle the precipitate, and filtering the uppermost water through muslin, linen, cotton duck, or sand. The precipitation of the iron is hastened by adding a little (determine the quantity by trial) limewater, a simple and safe solution obtainable at drug stores or easily and cheaply made at home. Limewater is prepared as follows: Put a small lump of fresh quicklime (caustic lime) in a wood pail and slake the lime by gradually adding about 30 times its weight of water. Stir or shake frequently during one-half hour, allow time to settle, and reject the liquid. Add to the lime residue about 300 times its weight of water, stir frequently during the next 24 hours, and allow the lime to settle. The clear water above the undissolved lime is limewater, and should be kept for use in large well-corked bottles or carboys. There is some saving if the undissolved lime is bottled with the limewater, every time some of the limewater is used adding a like quantity of fresh water.

Water containing iron can frequently be improved for laundry purposes by adding a little limewater or washing soda to the water in a tank or vat, stirring thoroughly, allowing the iron to settle to the bottom, and drawing off the uppermost (clearest) water for use. The water drawn off should be filtered through cloth or other material, but this is not always done because of the inconvenience. Long boiling of water is an aid to the precipitation of iron, but the method is generally impractical. Apparatus for the removal of iron is upon the market, and the names and addresses of manufacturers can be obtained from trade directories on file in many public libraries.

Iron removal and water softening are subjects not easily understood by the ordinary individual. Examination of the water is always necessary to determine the proper treatment. (See page 37.) The apparatus and piping should be adapted to the work to be done, and should be suitably housed to protect from frost. The apparatus is costly, and its operation can not be neglected. Individuals who can afford such plants or groups of farmers combining to install them can obtain very good results, provided proper attention is given to the operation of the plant.

PIPES AND FITTINGS

Galvanized wrought-iron or steel pipe screwed into galvanized, beaded, malleable-iron fittings is generally used for farm water piping. At greater cost, more lasting, cleaner-bore pipe, such as cast iron, brass, tin-lined lead, or cement-lined wrought, is available. Some of these pipes and the more common screw fittings are shown in Figures 25, *F*, *G*, *H*, *I*, and *J*. Further information on pipe materials and sizes and methods of jointing, laying, and protecting pipes is given in Farmers' Bulletin 1426, "Farm Plumbing."

3rd.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1449

SELECTION OF
COTTON
FABRICS



THE GREATER PROPORTION of textiles bought by the average family and most of the garments made in the home are of cotton. Therefore, the careful selection of these materials means the saving not only of money but also of time and effort of the housewife. This bulletin gives information concerning those details of cotton-fabric composition and construction which determine the durability and general usefulness of such materials. It also contains a list of cotton fabrics classified according to their appropriate uses and a glossary of the more important materials.

Washington, D. C.

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SELECTION OF COTTON FABRICS

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OVER eight billion square yards of cotton goods are manufactured and used in this country annually. The great variety of materials and qualities available each season is ample proof of the efficiency of the industry. However, this variety is in itself confusing to the consumer, and the selection of the particular piece best suited to the needs of an individual or a family requires careful thought.

APPROPRIATE FABRICS FOR VARIOUS USES

A fabric must be suitable for the purpose intended or it will not be satisfactory. Cotton, because it is durable, low in cost, and adaptable to many methods of cloth construction, is suitable for an enormous variety of purposes, as shown by the large number of named cotton fabrics on the market. The following list, classified according to suitability, includes the more standard fabrics, but does not, of course, give those that come and go each season. Names such as "flaxon," "India linen," and "silkaline" have been omitted purposely, since their use in connection with fabrics composed entirely of cotton is not considered advisable. All textile trade-mark names are also omitted. Definitions of the standard names are given on pages 19 to 24.

PROTECTIVE CLOTHING (COATS, SUITS, AND OTHER WRAPS)

For women and children.—Bedford cord, corduroy, crash, denim, duck, drill, piqué, pongee (cotton), poplin.

For infants.—Bedford cord, corduroy, gabardine, galatea, piqué, pongee (cotton), poplin, serge (cotton).

OUTERCLOTHING

Dresses for women and girls.—Agarie, albatross (cotton), calico, Bedford cord, challie (cotton), chambray, chintz, crash, crêpe, dimity, duck, éponge, étamine, foulard (cotton), gabardine, galatea, gingham, granite cloth, grenadine, lawn, middle twill, organdie, percale, piqué, pongee (cotton), poplin, ratiné, seer-sucker, serge (cotton), swiss, voile.

Dresses and gowns for infants.—Batiste, dimity, lawn, swiss, voile.

Shirts for men and boys.—Broadcloth shirting, cheviot shirting, gingham, hickory, khaki, madras, middie twill, Oxford shirting, percale, pongee (cotton).

UNDERCLOTHING

For adults and children.—Batiste, cambric, crêpe, dimity, longcloth, muslin, nainsook, shaker flannel, Canton flannel, outing flannel.

For infants.—Birdseye diaper cloth, Canton flannel, shaker flannel, outing flannel. (See dresses.)

NIGHT CLOTHING

Crêpe, longcloth, muslin, nainsook, Canton flannel, shaker flannel, outing flannel.

LININGS

Cambric, crinoline, lawn, nainsook, net, sateen, silesia, venetian.

HOUSEHOLD PURPOSES

For bedding.—Muslin, muslin sheeting, ticking, venetian.

For curtains.—Bobbinet, cable net, casement cloth, challie (cotton), cheese-cloth, dimity, filet net, gingham, marquisette, scrim, voile.

For draperies and upholstery.—Armure, chintz, crash, cretonne, madras, monks' cloth, poplin (cotton), rep, terry cloth.

For towels.—Crash, glass toweling, honeycomb toweling, huckaback or huck, terry cloth or Turkish toweling.

FABRIC CONSTRUCTION

Cotton cloth is made by removing the hairs from the seeds of the cotton plant, twisting these hairs into yarn, weaving the yarns into a fabric, applying a stiffening mixture, and ironing between large rollers. The nature of the fibers used and every one of the manufacturing processes affect the value of the fabric and should be considered when a cotton cloth is being purchased.

FIBER

Since cotton is the cheapest common textile fiber it is usually not adulterated; but sometimes it has been so treated as not to be easily recognized, or other fibers have been mixed with it for various reasons.

Mercerization is the process that changes its appearance and properties most markedly. It is so named because John Mercer discovered many years ago, that, when cotton yarn or cloth is dipped in strong solutions of lye for short periods of time and then properly washed, neutralized, and dried, it becomes much stronger. In later years it was noted that, if the yarn or cloth is held under well-regulated tension during the process, it is rendered glossier as well as stronger. Since the process adds not only beauty but also durability, there are to-day on the market many cotton fabrics in which the entire cloth is glossier and stronger than ordinary cotton materials, or in which these bright yarns have been introduced to form stripes, checks, or figures. The more or less temporary glossy finishes applied to fabrics by means of paste mixtures should not be confused with mercerization; nor should artificial silk, which is an even more lustrous fiber, be mistaken for mercerized cotton.

Artificial silk, now commonly called "rayon" by the trade, has been known in the past as fiber silk, glos, and by other trade terms. It is an artificial fiber made of wood pulp or cotton linters. In general the process consists of so treating the cotton or the wood pulp that it can be dissolved and a stiff liquid obtained. This is then forced through minute holes and the tiny streams thus produced hardened by passing them into certain solutions or into rooms of high enough temperature to remove the solvent. In most cases the product has the same chemical composition as cotton or wood pulp. It is glossy, but not very pliable and tends to fray unless well bound down in the weaving. It is not so durable as cotton, some types being very much weaker when wet and requiring special precautions during laundering. However, the artificial-silk industry is in the process of development, and the product is being rapidly improved.

Paper may be found in many novelty fabrics (fig. 1). It is cheap and although when properly finished will withstand a great deal of wear, it is weakened by water and pulled apart by the friction of ordinary washing processes.

Wool and silk are often combined with cotton; but since they are more costly, such a fabric is usually classed as wool or silk and is not considered here.



FIG. 1.—An imported drapery fabric with cotton warp and paper filling which will not withstand repeated laundering

IDENTIFYING THE FIBER

In order to find out what fibers have been introduced into a fabric, unravel the fabric and separate any yarns that appear to be composed of different materials.

Cotton yarns are fuzzy, owing to the projecting ends of the short fibers. They break easily, leaving a brushlike end. Paper yarns are usually made by twisting a strip of paper, and, therefore, are easily recognized when untwisted. Artificial-silk yarns untwist very readily, and the individual filaments spread apart in more or less fan shape. Mercerized cotton yarn is more glossy and stronger than untreated cotton yarn, whereas artificial silk is extremely glossy, weaker than cotton, especially when wet, more stiff and less pliable.

All of these fibers burn with a flash, leaving a very small pointed end. An exception is a brand of artificial silk recently introduced, which gives a hard ball of ash. Artificial silk can readily be distinguished from true silk by burning, as the latter leaves a larger quantity of ash in the form of a ball and gives off the odor of burning feathers.



FIG. 2.—Effect of wear and laundering on fabric containing a cord heavier than the adjacent yarns

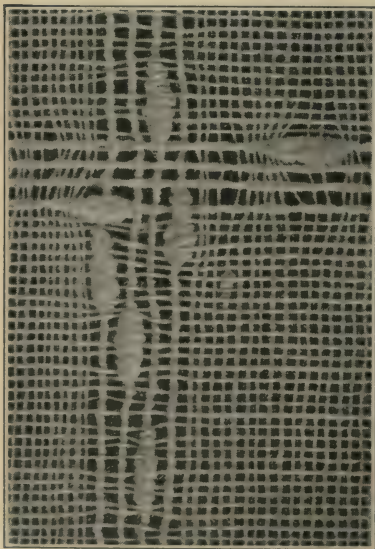


FIG. 3.—A novelty fabric containing irregular yarns which reduce its durability

JUDGING THE FIBER

The cotton fiber is a short tube tapering off to a closed point at one end. As the cotton ripens, the fluid that was originally in the tube dries, the walls collapse, and the fiber twists. This twist is an excellent characteristic, as it helps to hold the fibers together and makes a stronger yarn.

Unravel a yarn from the fabric, untwist it, and pull out small tufts of the little fibers which, after all, are the basis of the fabric. Notice whether the fibers are of about the same length or whether this varies a great deal. Compare their average length with that of fibers taken from another fabric. At best cotton is a short fiber, varying in length from $\frac{3}{4}$ to $1\frac{3}{4}$ inches, depending upon the variety and conditions under which the cotton is grown.

Choose the fabric with the longest fibers of regular length. The finest and best fabrics will have the finest and longest fibers. Short fibers tend to make weak yarns. Their ends become separated from the body of the yarn and give a fuzzy appearance as soon as the starch (sizing) added by the manufacturer is removed in laundering. Not only is this fuzzy effect unsightly, but the fabric catches dirt and becomes soiled more readily.

YARN

Cotton yarns vary in size, regularity, strength, elasticity, and amount of twist. The size of the yarn is called the count and is

specified by a numerical system. If 1 hank containing 840 yards weighs 1 pound, the yarn is numbered 1. If 2 hanks weigh 1 pound, it is a No. 2. Thus the finer the yarn, the larger is the count. Yarns numbered from 1 to 20 are known as "coarse yarns" and those from 21 to 40 as "medium yarns." "Fine yarns" are any of higher count than 40s, although the 41s to 60s range is usually known as "medium fine." The count of the yarns used in a fabric depends upon the purpose of the fabric and the design to be developed. The more fiber of a given diameter in each yarn, the heavier that yarn is and the more space it will cover, but also the coarser the fabric will be. Since the strength of the yarn, however, depends more upon the friction developed between the different fibers than upon the strength of each individual one, a large number of fine, well-developed fibers is an advantage in a yarn.

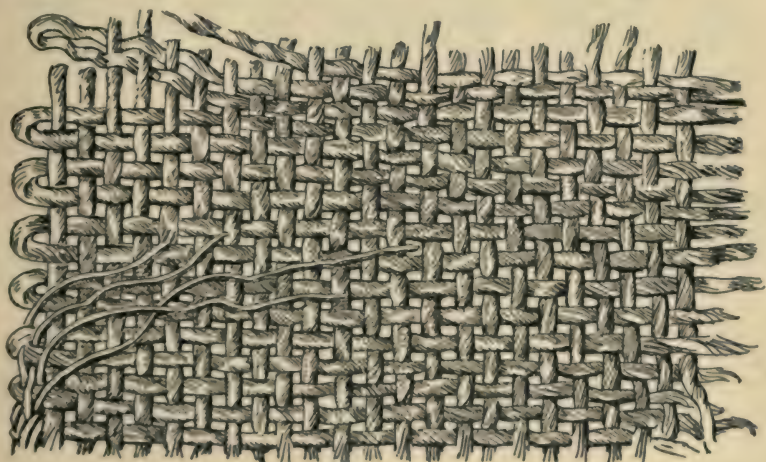


FIG. 4.—The plain or tabby weave

It is also well to notice whether yarns of greatly varying count have been used in the same fabric. Very coarse yarns are sometimes introduced in fine fabrics in order to produce stripes or checks; as, for example, in dimities and poplins. In poorer grades there is a tendency for the finer yarn to break, because the coarse yarn raises the surface fabric at that point and thus exposes itself and the fine yarn crossing it to excessive rubbing and wear. A portion of a handkerchief with this construction is shown in Figure 2. The cord in the border is entirely too heavy for the rest of the fabric and caused an early break which rapidly destroyed the fabric.

Irregular yarns produce lumps which are exposed above the surface of the fabric and wear through quickly. A fabric containing a number of these irregular yarns is shown in Figure 3.

Knots occur in all yarn. In weaving, the warp yarns are under great tension and often break. This also happens occasionally in the filling yarn. The weaver must repair these breaks by tying the two ends of the yarn together. A skillful operator makes a knot that is buried in the fabric, but in cheaper cloths sold as seconds

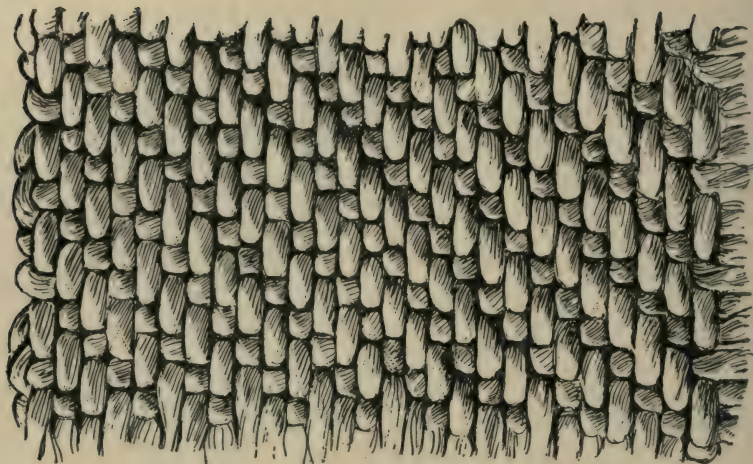


FIG. 5.—The twill weave

these knots often stand out on the surface, where they are worn off or pulled out, thus leaving holes.

In making a choice between two fabrics, strength is often the deciding factor; and it should be remembered that the strength of each yarn contributes to the strength of the whole. A yarn may be weak, owing to such conditions as weak fibers, poor construction, or improper bleaching. Twist adds strength up to a certain point and tends to bind the fibers more closely into the mass. Filling yarns are likely to contain too little twist as this reduces the covering power of the yarn. A small amount of twist in the yarn produces a fabric that soils easily. An elastic yarn recovers its length more or less after distortion and therefore gives a fabric more permanent form.

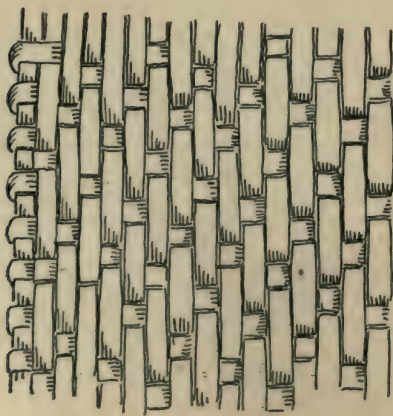


FIG. 6.—The satin weave

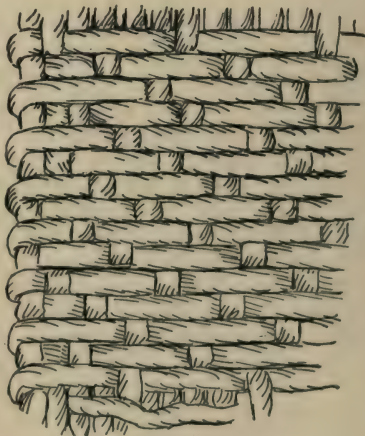


FIG. 7.—The sateen weave

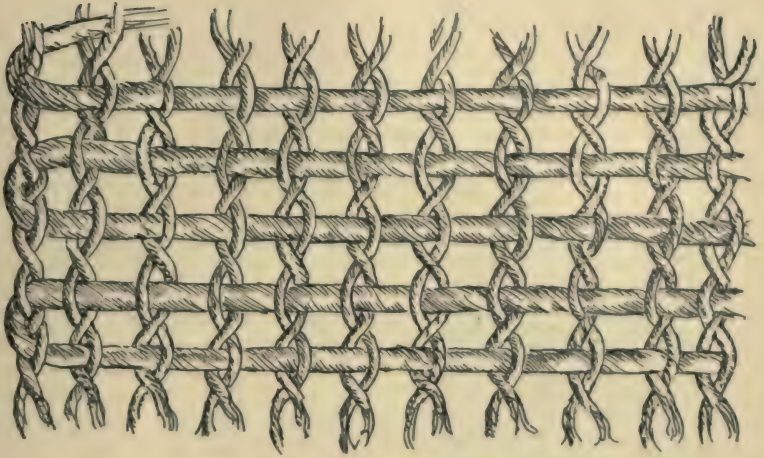


FIG. 8.—The gauze weave

JUDGING THE YARN

Study the fabric carefully, holding it against a strong light if it is thin, and note the characteristics of the yarn. Ravel out a few yarns, break them, and compare the strength with yarns from another similar fabric.

WEAVES

Weaving is the interlacing of yarns to form a fabric, and ranks with knitting and felting as one of the chief methods of producing cloth. In weaving, a set of yarns is held parallel to each other in the loom and is known as the warp yarns, the chain or the ends. Through these the filling yarns, sometimes called "the weft" or "the picks," are interlaced by means of a shuttle. Since this is the



FIG. 9.—The leno weave

means of binding one yarn to another, it is a most important factor in the final value of the fabric.

The three main types of weaving are plain, twill, and satin. The demand for beauty and sometimes mere novelty in textile design, however, has brought about many variations of these, some of which unfortunately are neither artistic nor durable.

In the plain, or tabby, weave (fig. 4) the filling yarns pass alternately over and under the warp yarn with each succeeding filling. This produces a fabric with the greatest amount of binding and therefore with the greatest breaking strength, though not with the greatest tearing or ripping strength, since there is less slippage between the yarns. No figures are available showing the comparative resistance to wear; but experience shows that, if regular yarns of almost similar count are used, a very durable fabric is produced. Fabrics of this nature may have defects of yarn structure (p. 4), and a loose, plain weave may result in a sleazy cloth.

The basket weave, in which two or more adjacent warp and filling yarns are woven in as though they were one, is a popular variation of the plain weave, particularly effective in coarser materials, as shown in the cover design. Ribbed weaves in which a group of either filling or warp yarns is treated in this way are also common. These ribbed weaves have the same weakness as heavy yarns combined with finer ones which cause a portion of the fabric to lie above the surface and thus be exposed to more wear (p. 5).

In a twill weave, the filling passes over and under different numbers of warp yarns with regular variation, so that diagonal lines are formed across the fabric. For example, the filling may pass over one warp yarn and under two, then over the next warp yarn and under two more. The next row would do the same, only passing under the first warp, then over the next, under the next two, and so on (fig. 5). The slant of the diagonal lines depends upon the number of yarns the filling passes over and under and whether the warp yarns are finer and closer together than the filling, or the filling finer and closer together than the warp. In fact, an enormous variety of twills can be produced by using yarns of different counts and twists, and combining other weaves with the twill. Undulating, broken, corkscrew, and herringbone twills are common. All of these can be found in cotton fabrics, although the twill is more common in worsted materials. A twill weave is decorative, firm, and strong. It does not have the breaking strength of the plain, but has greater tearing and ripping strength. It soils less easily than plain weaves, but is more difficult to launder. It is especially adapted to heavy skirtings and children's play clothes.

The satin weave is related to the twill, the filling yarns passing over and under a varying number of warp yarns in an irregular fashion that throws unbound yarns of various lengths to the surface. The satin weave, however, does not have the characteristic diagonal effect of the twill. The method of interlacing either produces patterns of various kinds or is so irregularly arranged that merely a plain surface is obtained. If two or more stitches are brought together, one above the other or side by side, a so-called double satin is the result. In a single satin the warp lies more on one side and

the filling on the other. When properly constructed, a satin weave produces a fabric not only durable but very beautiful, its most marked characteristic being the smooth, lustrous surface which the word "satin" invariably calls to mind. However, if the unbound yarns, known as floats, are very long, there is danger of their being caught and torn. This is the greatest weakness of the satin weave and must be considered when the fabric is purchased.

If by this method of weaving the filling yarns are thrown to the surface more often, the weave may be termed "a sateen," as distinguished from a typical satin weave in which the warp is thrown to the surface (figs. 6 and 7). However, this use of the terms is passing, and a fabric of this weave containing part cotton is usually considered a sateen regardless of the type of float.

The gauze and leno weaves are also common in cotton materials. They are produced by introducing extra warp yarns which twist around the ordinary warps where the weft yarn passes through. The terms are frequently used interchangeably, although in a typical gauze weave (fig. 8) two warp yarns cross each other between the weft yarns, the extra warp passing over every weft. In a typical leno weave there are warp yarns woven in plain, an extra warp passing from one side to the other of each of these, at the same time passing over alternate weft yarns (fig. 9). A combination of the gauze or leno weaves with other

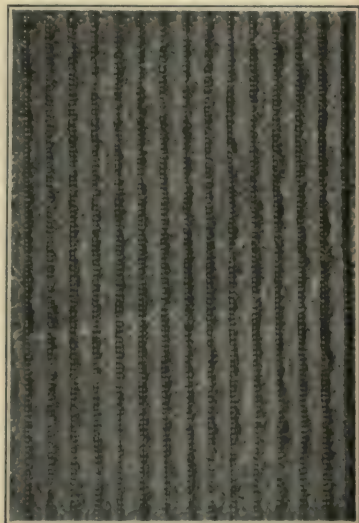


FIG. 10.—Corduroy, a typical pile fabric

weaves, usually the plain, to obtain a more lacy effect is sometimes termed "leno" or "fancy leno" when the above distinction is not made. Owing to the extra binding, the gauze and leno weaves are strong and are wise selections if open fabrics are desired. However, in some cases, the fancy lenos sacrifice durability in order to give a more pleasing appearance.

Pile fabrics (fig. 10) represent a variation of the plain or twill weave. They include those in which either cut or uncut loops extend above the surface. These may be formed by extra weft or extra warp yarns. Most cotton pile fabrics have the extra weft, the best examples being corduroys and velveteens. In such fabrics extra weft floats are left which, when sheared, provide the cut ends of the pile. A twill back permits the pile to be bound in more securely. However, the plain woven back is very common. When the pile is formed by the warp yarns, two sets of warp are usually employed. One set is held in the loom at ordinary tension, while the other is looser and forms loops when the weft is beaten into place. Such a material may be double faced or single faced. Terry or Turkish

toweling is made this way. The loops may be left over the entire surface or distributed in stripes and checks. The fact that the extra surface obtained by this method increases the ability of the fabric to absorb moisture makes the materials valuable as toweling. Another method, more commonly used in carpets, is to insert small

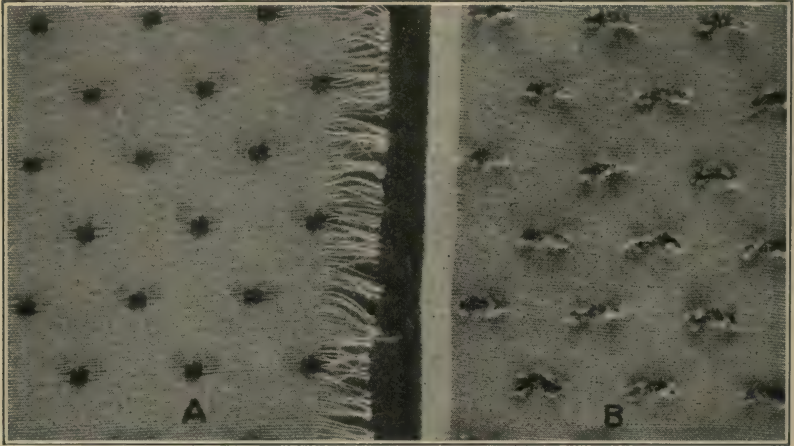


FIG. 11.—Right (A) and wrong (B) sides of fabric showing clipped dots, likely to be pulled out by wear and laundering

wires over which the extra warp passes. When these are withdrawn, more perfectly formed loops are left. If the cut pile is desired, knife edges may be slid in through grooves in the wire and the loops cut without injury to the body of the fabric.

The durability of these fabrics depends entirely on whether sufficient binding yarn is used and is beaten in tight enough to hold the pile. In some cases special precautions have been taken which give excellent results; in others the loop and pile yarns are very easily pulled out of place and the fabric is therefore undesirable. This point should be noticed especially in the case of toweling which must stand hard wear and frequent laundering.

Dots and figures may be produced by variations in the fundamental weaving processes as well as by dyeing and printing devices (p. 15). One simple method is to discontinue the interlacing at uniform intervals, allowing the filling and warp yarns to float unbound across the figure. In a very closely woven fabric this may be done successfully, but usually such fabrics are unsatisfactory. Extra warp or filling yarns may be introduced which continue throughout the entire length or breadth of the fabric, floating on the under side when not needed to form the figure. After leaving the loom, such fabrics are usually run through a machine which clips off this extra material from the under side, producing a "clipped" figure (fig. 11). If the extra yarns are about the same size as those used in the fabric and if it is closely woven, such figures are durable. However, the figures always consist of many short lengths of yarn, and these are more or less readily pulled out.

Figures may be embroidered on a piece of material by an embroidery machine. If only short lengths of unbound yarn are necessary to produce the design, a durable fabric is obtained. The one connecting yarn which floats on the back between the figures may or may not be clipped.

Lappet weaving, in which the designs are stitched on by a set of needles, is easily distinguished by the fact that the extra yarn proceeds lengthwise down the fabric in a zigzag fashion. The figure is not reversible, the extra yarn passing under only one filling yarn at a time, and thus lying almost entirely on the right side of the fabric. The figure may be continuous or the yarn may be clipped between separate designs (fig. 12).

Swivel weaving (fig. 13) differs in that the figures or dots are woven in by tiny shuttles carrying the extra weft, thus producing a result which is usually substantial. One continuous yarn forms the entire figure, unless different colors are introduced. This one yarn may extend to the next figure or may be clipped. It is usually conceded that swivel weaving produces the most durable figures, but it requires expensive machinery.

JUDGING THE WEAVE

Ravel out a small portion of the fabric carefully and classify the weave. Then, keeping in mind the possible defects, study the construction thoroughly and determine whether it is the best of its type. Pull the fabric between the hands and note an excessive amount of

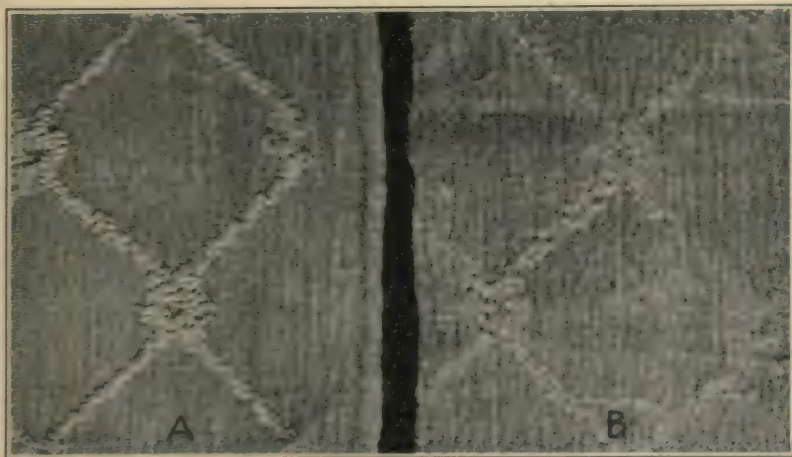


FIG. 12.—Typical zigzag design produced on right side of material (A) by lappet weaving. Complete figure does not appear on wrong side (B)

slippage. Scratch it with the finger nail. If the yarns are readily displaced, the fabric will fray at the seams when used in a garment. Notice the number of yarns per inch both weft and warp way. The closer the weave the more durable the fabric, other things being equal. Excess shrinkage is due chiefly to looseness of weave.

KNITTED FABRICS

Although most cotton fabrics are woven, there are many knitted ones. These are used principally for underwear, although there are some now in vogue for outside garments.

Knitting differs from weaving in that one yarn forms the entire fabric by being fashioned into a series of interlocking loops (fig. 14). Because a knitted fabric is very elastic and porous, it is particularly good for underwear. Since the knitting may be closely or loosely

done, fabrics can be made of many different weights. They can also be napped on one or both sides, thus making them very warm.

The disadvantages lie in the fact that if the one yarn is broken large holes may be formed very quickly. The fabric is also more easily pulled out of shape than is a woven material. For this reason it is well to choose a closely knitted fabric of firm yarn structure.

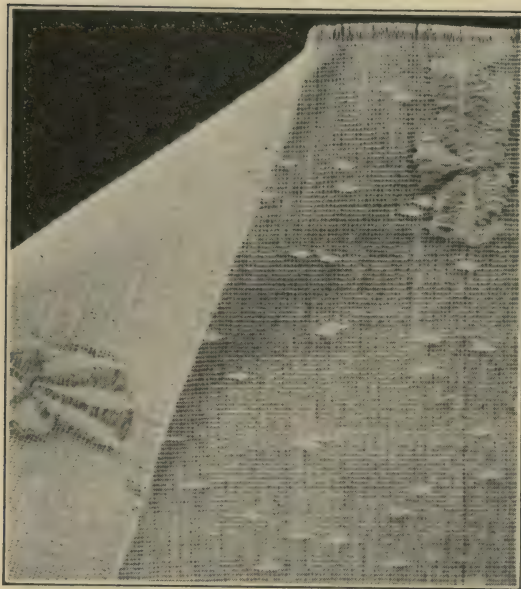


FIG. 13.—Figures produced by swivel weaving

FINISHING

The term "finishing" usually includes all the mill processes

through which a fabric passes after it leaves the loom. Dyeing, however, is often considered separately. Therefore the finishing of cotton materials may involve bleaching, mercerizing, waterproofing, fireproofing, or the application of various sizing mixtures to produce special surfaces. It may also include such mechanical treatments as napping and embossing. In fact, there are over a hundred different finishing processes in common use.

Cotton may be bleached in the raw state, in the yarn, or as the completed fabric. Then, too, even if the raw cotton or yarn has been bleached, the fabric may be run through a second bleach in order to clear up any discoloration. Occasionally bleaching is improperly done and the cotton attacked in such a way that the strength of the fabric is lessened. When durability is the prime consideration, unbleached fabrics are preferable.

Mercerization (p. 2) may be done while the cotton is in the yarn or after the fabric is made. As mentioned before, this process adds

materially to the strength of the fabric and may be done so skillfully that it resembles silk, and when specially calendered (ironed between heavy rollers) makes a good imitation of linen. Recent patents have introduced finishing processes in which the fabric is treated alternately with sulphuric acid and the lye used in mercerization. By carrying this out under special conditions, transparent effects are produced which make possible many novelties.

Waterproofing¹ and fireproofing are complicated processes, although they may in some cases be carried out satisfactorily in the home. Since cotton is very inflammable, the use of more fireproofed material where there is any danger of contact with fire is to be recommended. At present there is only a very limited number of such materials on the market.

Sizing includes the application of stiffening mixtures to the warp yarns in order to strengthen them for weaving, and also to the

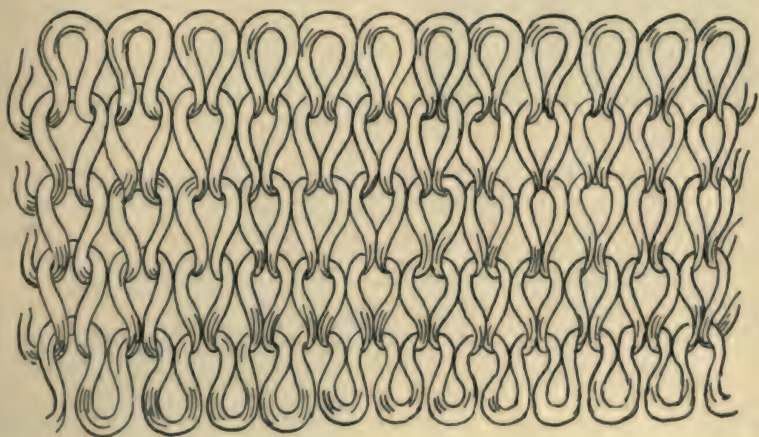


FIG. 14.—The plain knitting stitch

finished fabric to give body and a satisfactory feel. The mixtures commonly used contain some kind of starch, a softening material such as tallow or glycerine, a compound to prevent mildew, and materials to add weight. In fabrics such as paper cambrics and buckram, extra weight is desirable, but in most cases the real nature of the cloth is concealed by weighting. If such a fabric, with a loosely woven, coarse foundation is laundered, all its beauty and its usefulness are lost and the purchaser finds that a false value has been ascribed to it.

Patented processes employing albumin and casein solutions produce fabrics with more permanent stiffness, such as some of the best grades of organdie.

Napped cotton fabrics, such as cotton blanketing or outing flannel, are produced by passing the fabric through a napping machine

¹ Waterproofing and mildewproofing of cotton duck. H. P. Holman, B. S. Levine, and T. D. Jarrell. U. S. Dept. Agr., Farmers' Bull. 1157.



FIG. 15.—Blanket fabric before it is napped

which, by means of wire brushes, roughs up the fiber. This process, of course, removes fiber from the body of the fabric, and if carried to an extreme or if done on a thin fabric would soon destroy it. When heavy nap is desired, the foundation fabric must contain heavy yarns, with enough fiber to admit of dividing it between the nap and the foundation (fig. 15).

The warmth of a blanket depends largely upon the thickness and fluffiness of this nap and is greatly reduced as wear and laundering mat down and remove nap. Some commercial laundries have napping machines through which they pass blankets in order to produce as much nap as they had originally and thus restore their warmth. This is helpful, but can not be done indefinitely,

as every napping removes fiber and tends to wear through the foundation. The structure of the foundation fabric is therefore important and should always be carefully examined before a napped material is purchased.

Heavily napped cotton resembles wool very closely. At present there are many lightly napped cotton dress flannels on the market and napped twills made to resemble suede leather (fig. 16).

JUDGING THE FINISHING

Although efforts are continually being made by the industry to produce permanent finishes, these have not always been successful. One of the best ways to demonstrate the permanence of the finish and prevent disappointment, is to wash a sample of the fabric. Excessive weighting material can often be noted by rubbing the fabric between the hands or holding it where a strong light can shine through it. Improper bleaching can be detected by gently pulling the fabric both ways and noticing any weakness. Napped fabrics are often mistaken for pile ones. If the latter are well constructed, they wear much longer than napped materials.

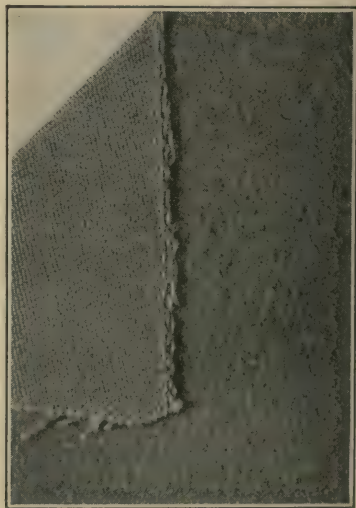


FIG. 16.—Cotton material napped to resemble suede leather

DYES

The dyes used to color a cotton fabric determine in many cases the satisfaction obtained from it. Whether or not they are "fast" is a matter which must be considered, but this term is often very loosely used. A dye that is really "fast" would remain permanently on a fiber under all conditions. No dye yet discovered will do this, and such permanency is not needed for ordinary purposes. On the other hand, it is essential that the dye last during the lifetime of the fiber and withstand the conditions under which the fabric is used, but not necessarily others. For example, a curtain fabric need not be fast to perspiration, but to give satisfaction it should be fast to light. In fact, the conditions should always be stated when fastness is mentioned.

Color may be introduced in a fabric either by dyeing or by printing. The chief difference is that in dyeing the material is soaked in a dye solution, while in printing the dye is part of a paste stamped onto the fabric or yarn by rollers of a printing machine. In general, dyed fabrics retain their original appearance much longer than printed ones, although the quality of dye may vary greatly in either case.

The dye may be applied to the raw cotton, to the yarn, or to the fabric. Under equal conditions dyeing the raw cotton allows better penetration and gives a more lasting effect, although when properly carried out either yarn or piece dyeing may be satisfactory.

Cotton fabrics are often printed in the piece. This can usually be seen by noticing that the back of the fabric is not dyed. However, yarns can be printed with colors at regular intervals, so that when they are woven into the fabric desired colors coincide and a design is produced. Sometimes mottled effects are so obtained.



FIG. 17.—A discharge pattern produced to resemble lappet weaving

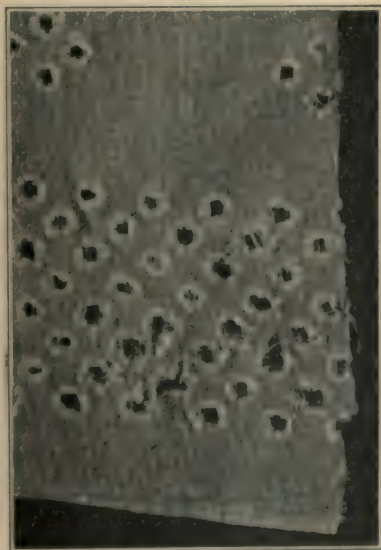


FIG. 18.—Worn places resulting from improperly produced discharge pattern

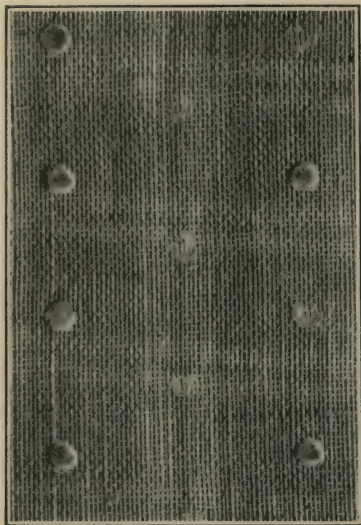


FIG. 19.—A fabric with paste dots discolored and in some cases removed by laundering

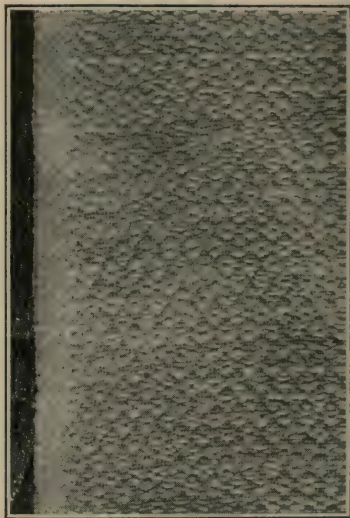


FIG. 20.—Birdseye diaper cloth

Discharge printing is also common on cotton fabrics. The cotton is dyed in the raw, in the yarn, or in the piece; then a paste, which by chemical action bleaches out a pattern, is applied with rollers. A discharge pattern produced in imitation of lappet weaving is shown in Figure 17. White dots or small patterns are often produced on dark backgrounds in this way. If this is not done wisely, the fabric may wear out quickly where the color was discharged. The worn

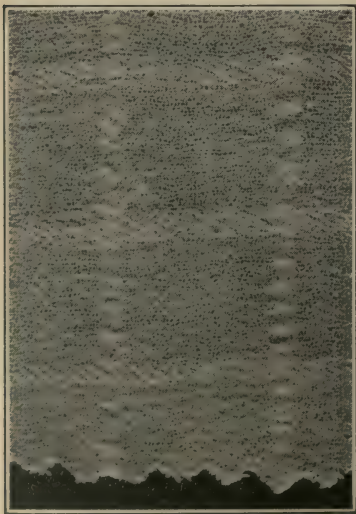


FIG. 21.—Crêpe

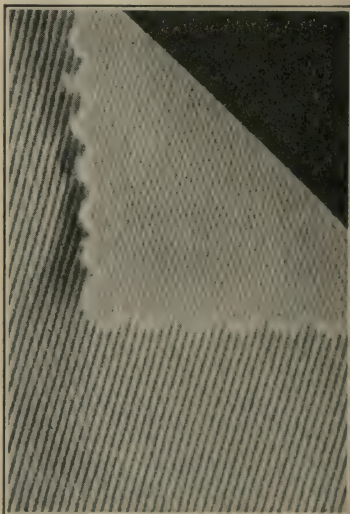


FIG. 22.—Gabardine, a typical twill weave

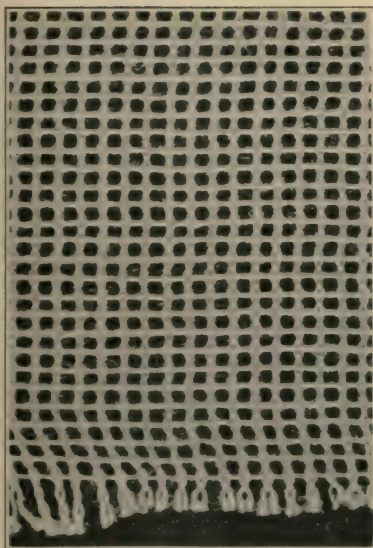


FIG. 23.—Marquisette, a typical gauze weave



FIG. 24.—Oxford shirting, a typical basket weave

places in the fabric shown in Figure 18 were originally white spots produced on a dark-blue background by discharge printing.

Raised colored or white dots and figures may be applied as a paste by similar machines. In some cases these wash or rub off easily, and such fabrics should not be chosen if they must be laundered often or exposed to much wear (fig. 19).

In both dyeing and printing, compounds called dyestuffs are used. Most of these are manufactured now, although some natural dyes

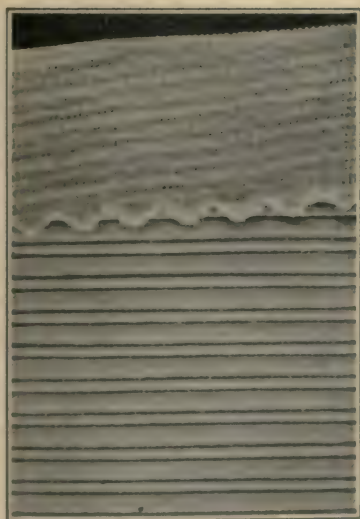


FIG. 25.—Piqué



FIG. 26.—Poplin

obtained from plants and animals are used. Many of the so-called artificial dyes have exactly the same composition as the coloring matters obtained from natural sources, and some of them are far superior. Thus the prejudice against artificial dyestuffs is unfounded and the longing for the natural dyestuffs of long ago a great mistake. Since dyes can be made from the compounds found in coal tar, they are often called "coal-tar dyes" and also "aniline" colors, because aniline is important in their manufacture.

The dyestuff found on a given cotton material may be any one of hundreds of possible compounds and to identify it exactly might be a laborious process. It can usually be readily placed by a chemist into one of the following general classes:

SUBSTANTIVE DYES

These are dyestuffs that will adhere to a fiber without the addition of a "handle" or mordant, a compound which, by combining with both the dye and fiber, holds the dye onto a fiber to which it would not otherwise adhere. These substantive dyes are further divided into four types:

Direct, or salt, colors are the easiest dyestuffs to manufacture and therefore the cheapest. They are, however, the most fugitive, and the difficulties experienced with certain cotton colors are usually due to the fact that a dye of this group is being used.

Sulphur colors are so named from the fact that they contain sulphur. They are more fast than the direct colors, but most of them are of dull shades and therefore somewhat limited in use. Sulphur blacks are very much used, especially in dyeing cotton hosiery. Under conditions of wear, they may liberate sulphuric acid, and some of the weakening of cotton fabrics so dyed can be attributed to this.

Vat dyes are the best cotton dyes known at present and are widely used on fabrics which withstand wear and launder well. They are the most difficult of all to make and are the most expensive.

Developed dyestuffs are valuable dyes obtained by rather complicated processes. The material, usually in the form of yarn, is thoroughly impregnated with one compound, then passed through various baths that react with the first and form a dye. Since the dye is thus made right on the fiber, it is very fast and compares well with many of the vat dyes in this respect.

ADJECTIVE DYES

Cotton is also dyed with the use of mordants, and such colors are very satisfactory. Tannic acid is a common compound used for this purpose, since it will adhere strongly to the cotton fiber on one hand and to the dye on the other. There are a number of such materials; but the common idea that salt, vinegar, alum, and some other substances used in household dyeing are mordants is erroneous. These are assisting agents which affect the shade and the quantity of dye deposited on the cloth, but they are not mordants. On account of the extra processes and therefore expense involved, dyes of this class are not used so extensively as some of the others.

The color of a cotton fabric depends entirely upon the chemical composition of the particular dye used. Every color is represented in each class with the exception of the sulphur colors, no successful

red sulphur dye having yet been made. The dyes in one class differ in properties from the dyes of another class, because they are of different composition.

It is a common fallacy that green, or some other color, is much less fast than blue. If these colors happen to belong to the same class, there is logic in such a comparison; but the consumer usually does not know to what class they do belong and may be comparing a member of the poorest class with one of the best. All green dyestuffs do not have the same qualities of fastness, not only because they may be members of entirely different classes, but also because individual members may differ slightly among themselves. Fastness is a matter of chemical constitution and not of color.

In this connection many housewives often speak of "setting" or "mordanting" a color and feel that they increase the fastness by soaking the fabric in alum, salt, or other solutions. These are not cotton mordants, and the effect produced is very slight and largely a waste of time.

JUDGING THE FASTNESS OF THE COLOR

The only way for a consumer to protect herself from unsatisfactory dyes is to take a sample of the fabric home and submit it to the conditions under which it is to be used. For example, cover a part of the sample with cardboard and expose the rest to direct sunlight for at least a week. Remove the cardboard occasionally, and compare the exposed and unexposed portions. Wash a sample under ordinary conditions and note whether it fades. Test a piece in a solution of Javelle water if the fabric is likely to require bleaching.

The method which has been used in dyeing the fabric can often be determined by unraveling a few yarns. If it has been piece dyed with poor penetration, there will be undyed spots where the yarns crossed in weaving. A piece-dyed fabric is always the same color throughout, including the selvage. If it has been yarn dyed with poor penetration, untwisting the yarn will reveal undyed fibers in the center, although the entire surface of the yarn may be properly colored. Often the color appears to wear off of such a fabric, owing to the fact that the outer surface of the yarn is removed and the undyed portions made visible. If the yarn has spots of different colors, it has been printed.

Thus, the wise selection of a cotton fabric must be based on general knowledge and appreciation of the fiber itself and of textile-manufacturing processes, including the new ones constantly being introduced. These technical facts must be supplemented also by the practical knowledge that comes from handling a great many fabrics and observing how they stand the wear and tear of everyday use.

GLOSSARY OF SOME COMMON COTTON FABRICS²

Ada or Alda canvas.—A stiff, coarse fabric usually of the basket weave, with accurately spaced square meshes. Tan or brown. Uses: Cross-stitch and other art needlework.

Agarie.—Loop pile fabric similar to a fine Turkish toweling. Loops formed by the warp. All colors. Uses: Dresses.

Albatross.—Soft, lightweight cotton fabric made in imitation of the worsted of

² This compilation was made in part from material found in the Dictionary of Textiles, Louis Harnuth; Cotton Fabrics Glossary, Frank P. Bennett; Fabrics and How to Know Them, Grace Denny; Glossary of Textile Terms, Harry P. Curtis; and from other well-known glossaries.

the same name. Plain weave with fleecy surface. Solid colors, piece dyed. Uses: Flags, bunting, kimonos, house dresses.

Apron checks.—Ginghams woven with small checks of white and blue or other single color. Usually made of coarser yarns than dress ginghams. Uses: Aprons.

Armure.—Related to rep. Woven figures produced by warp on a rep foundation. Plain or mixed colors. Uses: Couch covers, draperies, upholstery.

Art ticking.—See *Ticking*.

Bathrobe cloth.—Thickly napped double-faced blanketing. All colors. Uses: Kimonos, bathrobes.

Batiste.—Named from Baptiste, a linen weaver who is alleged to have first made it in the thirteenth century. Plain weave. Usually made of fine, high quality yarn. Soft, lustrous (mercerized) finish. White or delicate colors. Uses: Best grades, lingerie, infants' wear, sheer dresses; poorer grades, linings.

Bedford cord (cotton).—Heavy or medium weight fabric with raised cord or ridge effect running warpwise. White or colors. Uses: Children's wear, skirts, dresses, sport costumes, men's vests, shirts, soft collars.

Birdseye diaper.—Woven in typical birdseye pattern. Soft and absorbent. White. Uses: Diapers and when absorbent cloth is required. (Fig. 20.)

Bobbinet.—Netting with hexagonal meshes. Varies widely in fineness of yarns used and in closeness of mesh. White or colors. Uses: Curtains, linings, dresses, trimmings, veils, hat shapes.

Broadcloth shirting (cotton).—Resembles fine poplin but differs in that the warp and filling yarns are of the same counts and that there are at least 60 filling yarns to the inch. Plain weave with the warp much closer spaced than the filling. Fine ridges from selvage to selvage. White or colors. Uses: Shirts, dresses, skirts.

Buckram.—A plain weave fabric that owes its value to its heavy sizing of starches, gums, and glues. Black or white. Uses: Millinery frames, linings for stiffening garments.

Bunting.—Lightweight, soft fabric. Plain weave. Heavier than cheesecloth. All colors. Uses: Flags, decorative purposes.

Cable net.—Netting with coarse mesh; made of heavy yarns. White or colors. Uses: Curtains.

Calico.—Name derived from Calicut, India, where printed cloth originated. A plain-woven fabric of medium yarns. Usually printed in one or more colors on a white ground. Figure produced by "resist" and "discharge" printing also common. Uses: Dresses, aprons.

Cambric.—Name derived from Cambrail, France. Closely woven fabric of fine yarns with a characteristic soft finish. Generally firmer and of heavier finish than nainsook. Plain weave. Some qualities heavily filled and glazed. White or colors. Uses: Underwear, dresses, aprons, linings.

Canton flannel.—Twilled fabric woven of coarse yarns with long nap raised on one side. White or colors. Uses: Underwear, sleeping garments, linings.

Canvas.—Heavy fabric of coarse ply yarn. General term for heavier grades of cotton duck. Plain weave. White, with or without colored stripes. Uses: Sails, tents, awnings, hammocks. See *Ada canvas* and *Cross-stitch canvas*.

Casement cloth.—This term covers many drapery materials in various weaves and colors.

Challie or challis (cotton).—Soft-finished calico. An imitation of wool challis. Plain weave. Plain colors or printed

in all-over figured or floral designs. Uses: Draperies, linings, dresses, comforters.

Chambray.—Plain weave, smooth, shiny surface. Similar to gingham. No pattern, but colored warp and white filling. Always has a white selvage. Uses: Dresses, aprons, shirts, children's garments.

Cheesecloth.—Plain, loosely woven, thin, lightweight fabric. Yarns of same size as those in calico but much more open construction. White or colors. Uses: Curtains, flags, decorative purposes, linings, bandages, dust cloths, wrapping for cheese and butter.

Cheviot shirting.—Stout fabric of coarse yarn in imitation of wool cheviot. Plain or twill weave. Stripes or checks. Usually blue and white warp and white filling. Uses: Chiefly shirts, but also dresses and children's wear.

Chintz.—Hindu word meaning variegated. Plain weave. Starched and glazed. Printed in various designs, usually in bright colors. Uses: Draperies; more subdued patterns for dresses.

Corduroy.—Derived from French *corde du roi*, meaning "a king's cord." Twill or plain-woven foundation. Weft pile weave with rounded ridges or cords of the pile running lengthwise. White or colors. Sometimes printed. Uses: Suits, trousers, sport skirts, wraps, bathrobes, hangings.

Coutil.—French for "drill." Commonly known as "corset cloth." Constructed to withstand much wear and stretch. Varies from herringbone twills to elaborate Jacquard brocades. White or colors, with fancy stripes or figures. Uses: Corsets and other garments requiring great durability.

Crash.—Rough, closely woven fabric of coarse yarns. Usually plain weave. White, unbleached, or dyed. Uses: Dresses, hangings, art needlework; narrower widths, toweling.

Crêpe (cotton).—Lightweight fabric of crinkled surface. Plain weave. All colors. Uses: Dresses, kimonos, undergarments, sleeping garments. (Fig. 21.)

Cretonne.—Plain-woven fabric similar to chintz but not glazed. Sometimes twill weave. Printed in various colors, usually large designs. Uses: Hangings, upholstery, furniture coverings.

Crinoline.—Plain-woven fabric, highly sized with glue and starches. Dull or glazed. White, gray, or black. Uses: Inner linings, especially in millinery.

Cross-stitch canvas.—Heavy, open fabric. Plain weave. White or tan, with or without bars of colored yarn at intervals. Uses: Cross-stitching.

Damask.—Jacquard-woven fabric distinguished by the fact that the design shows on the smooth surface without the necessity of any contrast in color. White or colors. Uses: Tablecloths, napkins.

Denim.—Strong, warp-faced twill. Warp is usually blue or brown and the filling of "mock-twist" yarn. Some are made with white filling. A grade known as covert cloth is made with blue and white twisted warp yarns and dark-colored single filling. Uses: Overalls, work clothing; finer qualities, draperies, upholstery, and furniture covers.

Dimity.—Name derived from Latin *dimitum*, meaning "of double thread." A thin, sheer fabric with corded checks or stripes. White or colors. Uses: Dresses, aprons, curtains, lingerie, infants' wear.

Drill or drilling.—Heavy, durable twilled fabric of coarse yarns. White or colors. Uses: Trousers, skirts, middies, uniforms.

Duck.—So called because it sheds water. Heavy, coarse, plain-woven material. Usually with each alternate pair of warp ends woven as one. Often sold in grades by

weight, designated in ounces, or by number. White or colors. Uses: Harvester machine screens, tents, boat sails, awnings; finer qualities, skirts, suits, middies.

Eponge.—Soft, coarse fabric made with novelty yarns. Similar to ratiné. Plain weave. White or colors. Uses: Dresses.

Etamine.—French word meaning "bolting" or "sifting" cloth. Originally applied to cloth used for that purpose. Plain-woven, thin, glossy material similar to bunting. White or colors. Uses: Dresses, draperies.

Eiderdown.—Thick, soft fabric, knitted foundation, thick nap. White, plain colors, or colored patterns. Uses: Bathrobes, infants' coats, and blankets.

Filet net.—Square-mesh netting. White or colors. Uses: Curtains.

Flannel (cotton) or flannelette.—Plain-woven or twill-woven fabric with smooth or napped surface. White or colors printed on plain surface. Uses: Dresses, shirts, kimonos.

Foulard (cotton).—Highly mercerized fabric resembling silk foulard. Twill weave. Plain colors or printed. Uses: Dresses, linings, comforter coverings.

Gabardine (cotton).—Twill fabric. Fine but distinct diagonal cords. White or colors. Uses: Suits, skirts, wraps; may be waterproofed for raincoats. (Fig. 22.)

Galatee.—Firm, closely woven fabric of coarse yarns. Very durable satin (warp sateen) or sometimes twill weave. White and colors. Sometimes printed with stripes or other designs. Uses: Children's garments, skirts, suits, middies, uniforms.

Gingham.—Plain-woven fabric of yarns of medium counts. Stripes, checks, and plaids formed of dyed yarns. Uses: Dresses, shirts, children's garments.

Chambray gingham: Plain colored, white filling.

Nurses gingham: Blue and white stripes, closely woven.

Scotch gingham: Fine quality, made in Scotland.

Tissue gingham: Thin fabric with heavy cord.

Zephyr gingham (also French gingham): Fine, soft-finished fabric.

Glass toweling.—Plain-woven fabric of tightly twisted yarns. Glazed finish. White with red or blue stripes forming checks. Uses: Dish towels.

Granite cloth.—Fancy irregularly woven fabric; yarns twisted so as to give a pebbled surface. Various colors. Uses: Dresses.

Grenadine.—Similar to marquisette and commonly known by that name. Woven to give lacy effect. Leno or gauze weave. White or colors. Uses: Dress trimmings.

Hardanger cloth.—Basket weave. White or écaru. Uses: Hardanger embroidery.

Hickory.—Very stout, durable, coarse shirting. Twill weave. White, with usually blue or brown lengthwise stripes. Uses: Shirts, work clothes.

Honeycomb toweling.—Rough material. Twill weave with diamond patterns constituting the so-called honeycomb weave. White or colors. Uses: Towels.

Huckaback or huck.—Rough-surfaced fabric, usually honeycombed or with other geometrical designs. White or colors. Uses: Towels.

Jean.—Resembles drill, but finer. Stout and durable. Twill weave. White, plain colors, or stripes. Uses: Work garments, children's clothing.

Khaki-twill.—Khaki is East Indian word for "dusty." Used first in India. Twill weave. Strong fabric dyed yellowish tan. Uses: Uniforms, outing costumes.

Kindergarten cloth.—Plain weave, firm material, similar to gingham but heavier. All colors. Uses: Children's clothing, dresses.

Lawn.—Name derived from Laon, France. Fine, sheer fabric with crisp, linen-like finish. Plain weave. White, piece-dyed, or with printed designs. Uses: Dresses, underwear.

Linen-finished suitings.—Large class of fabrics sold under various trade names. Heavy with coarse yarns finished to imitate linen crash suitings. Vary in weight and finish. White or colors.

Longcloth.—Medium-weight, plain-woven fabric. Usually closer weave than batiste, fine muslin, or cambric, and with little or no sizing. White. Uses: Underwear, uniforms.

Lustrine.—Very smooth fabric. Satin weave. Warp yarns sized and polished in imitation of horsehair yarns. All colors, but usually black or striped. Uses: Coat sleeve lining.

Madras.—Originally a fabric made in Madras, India, for head dresses. Drapery: Thin material with figures of mercerized cotton or other fiber introduced on a leno-woven foundation. Floats are sheared between figures, leaving rough effect. White or colors with figures of same or contrasting shades. Uses: Curtains. Shirting: Plain or fancy woven fabric with characteristic white or colored warp stripes usually forming fine ribs. White, plain, or with colored stripes and figures. Uses: Shirts, shirtwaists, dresses.

Marquisette.—Lightweight fabric, open texture. Gauze or leno weave. Very sheer. The name is sometimes applied to coarse plain weaves commonly known as serim. White, écaru, or colors. Uses: Curtains, dresses. (Fig. 23.)

Marseilles.—Originally made in Marseilles, France. Heavily corded, double faced with raised pattern. White. Uses: Bedspreads.

Masalla cloth.—Fine material like nainsook. Slight luster. White. Uses: Infants' dresses, underwear.

Middy twill.—Twill fabric similar to drill or jean. White or colors. Uses: Children's clothes, skirts, middies.

Milanese or Monk's cloth.—Heavy, rough drapery material. Basket weave. White or dark shades. Also known as friars' cloth, druid cloth, and mission cloth. Uses: Draperies, upholstery. (Cover design.)

Mosquito netting (or bar).—Heavily sized, coarse, square-meshed fabric. Plain or barred. Leno weave. The most durable is a bobbinet. White or colors. Uses: Screens.

Mull.—Derived from word *mal* in Hindu, meaning "soft." Plain, sheer fabric, similar to lawn, but sized to give soft finish. Highly mercerized. White or colors. Uses: Dresses; starched mull, millinery purposes.

Muslin.—Named from city of Mosul. Plainly woven fabric. Variety of grades. Better qualities have little or no sizing. The same fabric may be so finished that it is given a different name, such as "nainsook," "batiste," "lawn." White or unbleached. Very fine qualities suitable for dresses either piece-dyed or printed. Uses: Underwear, sheeting, various household purposes.

Nainsook.—Derived from Hindu words meaning "delight of the eye." Soft, fine plain-woven fabric. Very slightly sized. Usually finer and lighter than cambric. May be mercerized. Often polished on one side. White. Uses: Dresses, underwear.

Organdy.—Very sheer, stiff, translucent fabric. Either heavily sized or specially treated to produce a characteristic

crispness. White or delicate shades. Uses: Dresses.

Outing flannel.—Plain-woven or twill-woven fabric. Heavily napped on one or both sides. White, plain, striped, or checked. Uses: Underwear, sleeping garments.

Oxford shirting.—Basket weave or twilled. Mercerized. White, plain colors, or stripes. Uses: Suits, shirts. (Fig. 24.)

Percalé.—Plain, closely woven, lightweight fabric with a dull finish. Contains more sizing than muslin but without the gloss of cambric. More closely woven than ordinary calico. White or printed either by direct or discharge method. Uses: Dresses, aprons, shirts, blouses.

Percaline.—Plain-woven, highly calendered percalé. Sometimes moiré. White or colors. Uses: Underskirts, linings.

Piqué.—French word meaning "quilting," since this fabric was originally woven to resemble quilting. Heavy, durable fabric with raised cords from selvage to selvage. White or colors. Plain or with stripes or figures. Uses: Skirts, dresses, infants' coats. (Fig. 25.)

Pongee (cotton).—An imitation of silk pongee. Plain woven with lustrous finish. Filling closer-spaced and of coarser yarns than warp. White or any color, but usually tan, similar to real pongee. Uses: Dresses, shirts.

Poplin (cotton).—Imitation of silk poplin. Ribbed across the cloth. Warp closer spaced and of finer yarns than the filling. Usually mercerized. White or colors. Uses: Dresses, suits, hangings. (Fig. 26.)

Ratiné.—Plain weave of specially twisted novelty yarn. Loosely woven. Always has tufts on the yarn which produce a rough surface. White or colors. Usually white yarn with mottled filling. Uses: Dresses, coats.

Rep (probably corruption of "rib").—Plain weave with heavy filling so introduced as to produce heavy ribs from selvage to selvage. Usually a large or distinct rib is alternated with a small one. Close-spaced warp, usually ply yarns, and very coarse single filling. White or colors. Uses: Upholstery, drapery.

Sateen.—Heavily mercerized fabric. Twill weave with filling thrown to the surface and the surface binding yarns so scattered as to give a smooth lustrous surface. Back shows twill. "Warp sateens" have the typical satin weave. White or colors. Uses: Underwear, draperies, linings.

Scrim.—Coarse, plain, open-woven, strong fabric. Usually mercerized. White, écu, or colors. Uses: Curtains.

Seersucker.—A thin fabric with crinkled stripes resulting from applying dif-

ferent tension to various warp yarns. Plain weave. White or colors. Uses: Night clothing, house dresses, shirts, children's garments; heavier qualities, men's suits.

Serge (cotton).—Cotton fabric with a decided diagonal rib effect. Twill weave. An imitation of worsted serge. White, dyed, or printed. Uses: Skirts, dresses.

Shaker flannel.—Originally a mixed wool and cotton fabric made by a religious sect known as Shakers. Now a cotton or union fabric. Plain or twill weave, napped on both sides. Usually softer and more loosely constructed than outing flannel. Also called "domet." White or colors. Uses: Underwear, night clothing, shirts.

Sheeting (cotton).—In the retail trade this term is usually applied to both bleached and unbleached muslin manufactured in widths suitable for bed sheeting. Plain-woven fabric in a wide variety of constructions, which is used for many household and commercial purposes.

Silence cloth.—Very heavy, double faced, napped on both sides. Made of coarse yarns. White. Uses: Table pads.

Silesia.—Closely woven, very smooth fabric. Twill weave. Highly glazed. White, piece or yarn dyed. Uses: Linings.

Swiss.—So called because first made in Switzerland. A fine muslin, very thin and transparent, stiff and crisp. Usually with pattern of dots or small figures. Genuine dotted Swisses made on swivel looms and imported from Switzerland. Various imitations made in this country. White or colors with white or colored dots or figures. Uses: Dresses, aprons, curtains.

Tarlatan.—Highly sized and calendered thin fabric. Wiry and transparent. Square mesh, plain weave. White or colors. Uses: Millinery, fancy dress garments.

Ticking.—Heavy, durable, twilled fabric, woven with herringbone twill. Usually blue and white warp stripes. White filling.

Art ticking.—Satin weave of close construction. Printed stripes or floral patterns of bright colors. Uses: Pillow and mattress covers.

Velour.—Similar to velveteen. Pile weave. Often has other material than cotton for the pile. All colors. Uses: Upholstery, draperies.

Velveteen.—Plain-woven fabric with very short pile. Imitation of silk velvet. White or colors. Uses: Dresses, suits, coats.

Venetian.—Mercerized, closely woven, durable fabric. Satin or twill weave. Very lustrous, silklike finish. White or colors. Uses: Linings chiefly.

Voile.—Light, sheer fabric. Crisp, "thready" feel. Open construction. White, dyed, or printed. Uses: Dresses, blouses, curtains.

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HOME BAKING



SOME KIND OF BREAD is served on the average American table three times a day. The quality of that bread is an important matter. The food value depends on the materials which go into it, whether it is made at home or in the bakery. This bulletin has been planned primarily as a guide in home baking, but through its discussion of materials it offers help also in the choice of commercial baked products.

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HOME BAKING

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Good bread for her family is one of the important concerns of the homemaker. This bulletin points out what makes for high quality and gives methods and proportions for making typical yeast breads, quick breads, cakes, and other baked goods at home. These main types may be varied in almost innumerable ways by the housekeeper by adding seasonings or by baking in different shapes and sizes. A great variety of recipes is not included; instead emphasis is placed on the general principles of baking, proportions, and ways of substituting various ingredients, such as soft-wheat for hard-wheat flour, so that the housekeeper can make economical use of the materials at hand.

FLOUR AND OTHER MILL PRODUCTS OF WHEAT

For making most kinds of bread and similar products wheat flour is superior to all others because of the two proteins in it which form gluten when the flour is made into a dough. This gluten is what gives the dough an elastic quality, so that it can expand and hold within it gas bubbles formed by yeast or other leavening agents. It is known to the farm boy as "wheat gum," which he makes by chewing the wheat kernels, and may be easily recognized as the grayish yellow substance left when the starch is washed out of wheat flour.

The bread-making value of different types of wheat flour depends on the quantity and the quality of the gluten that can be developed in them. For practical purposes these gluten-forming proteins in the wheat grain and flour are referred to as gluten, as though they were combined. Flours are called "strong" if they have a comparatively large quantity and good quality of gluten, and "weak" if their gluten is low in quantity or poor in baking quality.

The nature and the amount of gluten in flour depends both on the kind of wheat from which it is made and on the milling. The wheats which make

the strongest flours are grown mostly in the regions between the Rocky Mountains and the Mississippi Valley, north and west of Missouri. The wheats grown in the more humid areas between the Great Plains area and the Atlantic coast and most of the wheats of the Pacific coast are softer and less glutinous.

Out of any lot of wheat, either hard or soft, it is possible to mill several kinds of flour that differ considerably in their bread-making quality and in their food value. The present milling process is very complicated and highly specialized. The grain is broken up gradually by passing it between several pairs of rolls, and after each step in its reduction some separation of the material is made according to the size and character of the particles. In this process the bran and germ are usually removed, and the material milled from the remaining grain is combined or separated to form different commercial grades of flour. The two grades most commonly sold to the housewife are "straight" and "patent."

"Straight" or "straight run" flour usually contains about all of the grain except the bran, the shorts, and the germ, and is approximately 70 per cent of the total weight of wheat milled.

"Patent" flours are classed as "long patents" or "short patents," depending on what proportion they represent of the total flour milled from the grain. Certain streams which are utilized in the production of so-called clear flours are excluded from the patent flours, but are included in the "straight." A short patent may contain less than 50 per cent of all the flour milled from the grain, and is seldom made except for commercial bakers, who want a flour of maximum bread-making power. A longer patent, which contains perhaps 60 or 65 per cent of the total flour, is more common.

In the manufacture of either "patent" or "straight" flour the bran, the shorts, and the germ of the wheat are removed. This, of course, sacrifices

some food value, for most of the minerals and vitamins of wheat are contained in these portions. This loss may be compensated for, however, by the improvement in the baking strength of the flour.

Graham flour,¹ or wheat meal, as it is more properly called, contains all of the wheat and has some advantages from the point of view of food value over a flour that does not contain the bran and the germ. It does not, however, keep so well as white flour. In a diet that is limited in variety, and hence likely to be lacking in certain elements, some of the breads should be made from this kind of flour. In a diet containing plenty of milk, eggs, fruits, and vegetables the bran and the germ of the wheat kernel are not so essential, but even in this case breads made from graham flour add flavor and variety.

Bran, the dark, fibrous portion of the wheat, is less completely digested than the rest of the kernel. As bran is sold commercially it has some food value from the starch as well as from the minerals and vitamins associated with the fibrous parts, but it is used chiefly for its laxative properties. In moderate quantities, and especially as it comes ground up in graham flour, it is usually considered to be a desirable addition to the diet.

SPECIAL USES FOR STRONG AND WEAK FLOURS

Strong flours made from hard wheats are generally considered best for yeast bread, although with proper methods excellent results can be obtained with those from some soft wheats. For cake and pastry, in which tenderness is of prime importance, soft-wheat flours are usually the more successful. Quick breads, such as muffins or biscuits, may be made about equally well with either type.

It is difficult for a housekeeper to tell what type of flour she is buying, especially as those on the market vary all

the way from very strong to very weak. The flours from soft wheats have a velvety texture somewhat like cornstarch, and those from hard wheat are usually more gritty, but it requires some experience and a fine sense of touch to detect this difference. Experts usually do it by taking a pinch of flour and rubbing it lightly between the thumb and the third finger. Another way to tell is by squeezing a handful of it tightly and noticing whether as the hand is opened the flour remains in a mold and shows the impression of the fingers. In this test a hard-wheat flour acts more like a powder and the mold breaks up more readily than that of a soft-wheat flour. Weighing is still another method used to distinguish hard-wheat flours from soft. A quart of hard-wheat flour that has been sifted once, dipped lightly into the measure, and then leveled off, weighs about 16 or 17 ounces or even more. A quart of soft-wheat flour sifted and measured in the same way weighs only about 14 or 15 ounces.

It is much easier to get good results in baking if the methods used are adapted to the type of flour. When occasion demands, good yeast bread can be made from a comparatively weak flour or good cake from a strong one, by making sufficient allowance for the weakness in the former case and for the strength in the latter. The rules for substituting (pp. 6 and 9) apply to typical hard-wheat and typical soft-wheat flours.

COMPOSITION OF WHEAT FLOUR

The approximate chemical composition of different types of hard-wheat and soft-wheat flours is shown in Table 1. Though no indication of vitamin content can be given in such a table, experiments have shown that in general the highly refined flours contain practically none of the vitamins present in the whole-grain products.

TABLE 1.—Approximate composition of different types of wheat and wheat flour

	Carbohydrates (mostly starch)	Fat	Protein	Water	Mineral matter (ash)		Carbohydrates (mostly starch)	Fat	Protein	Water	Mineral matter (ash)
Hard wheat:	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	Soft wheat:	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
Grain.....	70.9	1.8	12.3	13.2	1.8	Grain.....	72.2	1.9	11.0	13.2	1.7
Graham flour (wheat meal)	70.9	1.8	12.3	13.2	1.8	Graham flour (wheat meal)	72.2	1.9	11.0	13.2	1.7
Straight flour...	73.7	1.1	11.5	13.2	.5	Straight flour...	75.8	1.2	9.4	13.2	.4
Patent flour...	74.6	1.0	10.8	13.2	.4	Patent flour...	76.7	1.1	8.7	13.2	.3

¹ The terms "whole wheat flour" and "entire wheat flour" may mean the same as graham flour, but at present these names are sometimes commercially used for products that do not contain all of the bran.

OTHER FLOURS AND MEALS USED IN BAKING

Rye ranks next to wheat as a bread grain because it contains similar proteins. In fact, rye flour is practically the only other kind that can be used successfully alone in yeast breads, and even it gives better results if mixed with wheat flour. Products from corn, oats, buckwheat, barley, rice, potatoes, peanuts, soy beans, and many other materials may be substituted for part of the wheat flour in yeast breads, and some of them can be used as the chief ingredient of excellent quick breads, where there is less need for gluten.² This is especially true when egg is used. Usually, however, even in quick breads, a mixture of wheat flour with the other material makes a lighter product.

MEASUREMENTS

3 teaspoons	= 1 tablespoon
16 tablespoons	= 1 cup (standard)
4 cups	= 1 quart

All quantities are given in level measurements.

Flour, except graham or whole wheat, should always be sifted once before measuring and then dipped lightly into the measure and leveled. If it is packed into the measure, too much will be used.

In measuring less than one-fourth of a cup of hard fat it is best to use tablespoons (one-fourth cup=4 tablespoons). When the quantity is between one-fourth cup and 1 cup, time is saved by measuring it in water. For example, if two-thirds cup of fat is required, put one-third cup of water into the cup first, and then add fat until the water comes up to the brim.

A table knife or other straight edge should be used to level sugar, salt, flour, and other dry ingredients.

YEAST BREADS

The points that are most important in yeast breads in addition to food value are lightness, good flavor and color, texture, and keeping qualities. The accompanying score card may be helpful as a means of showing how bread can be judged.

Score card for yeast breads

	Points
General appearance.....	10
Shape—roundness of "dome."	
Smoothness—no cracks, bulges, lumps, or the like.	
Color of crust—golden brown.	
Lightness.....	10

	Points
Crust.....	10
Thickness.....	
Quality—crispness and tenderness.	
Crumbs.....	5
Color—light cream color.....	
Texture.....	25
No streaks or extreme closeness of grain.	
Size and uniformity of cells, thinness of cell walls.	
Elasticity—softness and springiness.	
Flavor—taste and odor.....	30
Sweet, nutty flavor with no "off" taste.	
Keeping qualities.....	10
	100

INGREDIENTS OF YEAST BREADS

The essential ingredients in bread are flour, liquid, salt, and leavening. French bread illustrates that an appetizing product can be made from these materials with water as the liquid. In this country, however, it is customary to use sugar, shortening, and oftentimes milk.

Flours have already been discussed.

Liquid.—When milk is used as the liquid the bread is improved in food value and does not grow stale so rapidly as when water is used. From the nutritive standpoint, for instance, wheat is poor and milk is particularly rich in calcium, one of the important mineral constituents in which the diet is often low. Evaporated or powdered milk may be used when fresh milk is difficult to obtain. Bread made with potato water does not dry out so fast as that in which water is used as the only liquid.

Shortening.—The fat in bread makes it more tender and adds to its fuel value. Butter is sometimes used, chiefly for its flavor, but lard or any other good cooking fat is satisfactory.

Sugar.—A small quantity of sugar added to the dough makes it rise more quickly and helps to give a golden brown color to the crust. Some persons think that the flavor also is better when sugar is used.

Salt.—Salt is added for flavor. The yeast grows faster in bread dough when only a small quantity of salt is used, but there should be enough of it to bring out the wheat flavor.

Yeast.—Yeast, the minute cell-like plants put into bread dough to leaven it, may be bought in dry or compressed cakes or grown at home in the form of a "starter," or "liquid yeast." The dry cakes keep better than the other forms; but since the yeast cells are not growing actively, longer time

² Suggestions for using corn and rice products in baking are given in U. S. Dept. Agr. Farmers' Bul. 1236, Corn and Its Uses as Food, and Farmers' Bul. 1195, Rice as Food.

is required to make bread with dried yeast. The compressed is perhaps the most convenient to use if it can be obtained fresh. It is usually more expensive than the other forms, however, and it spoils rather easily. Many housekeepers also get excellent results with so-called liquid yeast and consider it a convenience and economy. Mixtures of this kind are discussed more fully in connection with the use of soft-wheat flours. In any case the yeast for bread making should be pure and in good condition.

FERMENTATION

As yeast causes bread dough to ferment, tiny bubbles of carbon-dioxide gas, which leaven the dough, and by-products, which change the character of the gluten, are formed. The latter fact is one of the reasons why dough made with soft-wheat flour must be handled somewhat differently than that in which hard-wheat flour is used.

Like all living things, yeast needs a favorable temperature as well as moisture and right food in order to grow vigorously. The best temperature for bread fermentation is probably between 80° and 85° F. Yeast grows faster at temperatures even slightly above 85° F., but when the dough gets warmer than this the conditions become more favorable to the growth of other less desirable organisms that may be present. If the temperature of the dough goes much over 95° F., the growth of the yeast is in danger of being retarded.

In order to keep the dough at a constant temperature of about 82° F. the bread bowl or pan may be covered and set in a vessel of water. Ordinarily, when the temperature of the room is much lower than 80° F., the water in the outer pan should be about 90° or 95° F. In hot weather, when the air is warmer than 85° F., the water should be slightly under that temperature. When a sponge or starter (p. 6) is allowed to stand overnight, it should be well protected against drafts and placed where it will be neither chilled nor overheated.

Since temperature is so important in bread making, the use of a thermometer is helpful. Experienced bread makers can often tell by the feeling when the temperature is right, but this method is not thoroughly dependable. A dairy thermometer is usually easy to obtain and not very expensive.

The rising of the dough should be stopped at the right point. If it is allowed to stand too long before it is "punched down," an unpleasant or

sour flavor may develop and the gluten will be injured. If the dough rises too high in the pan before it is put in the oven, it will be too coarse-grained; and if it does not rise high enough, the bread will be heavy.

The proper length of time for dough to rise depends on the vitality of the yeast, the temperature at which the dough is held, and the strength of the gluten. Volume, appearance, and feeling all indicate when dough has risen long enough. The best test is made by touching the surface of the dough lightly with the finger. If it has risen enough, a slight depression will remain on the surface. If the dough is still so elastic that the depression disappears quickly, it should rise a little longer. Dough made with very strong flour will reach about two and one-half times its original volume before this test is obtained, but dough made with rather weak flour will give the same test when about double its original volume.

PROPORTIONS AND METHODS

The following proportions will make about 3½ pounds of bread. A larger quantity of flour is required when soft-wheat flours are used (p. 6). The liquid may be milk, water, potato water, or any combination of these. All measurements are level:

About 2¼ pounds, or 2¼ quarts,
sifted hard-wheat flour.
2¾ cups liquid.
4 teaspoons salt.
2 tablespoons sugar.
2 tablespoons fat.
1 ounce (2 cakes) yeast.

From these ingredients bread may be made by various methods. The common standard ways, known as the straight-dough and the sponge methods, are described here and suggestions given for varying them.

STRAIGHT-DOUGH METHOD USING COMPRESSED YEAST

With the ingredients in these proportions and with the temperature about 82° F. bread can be made by the straight-dough method in about four hours from the time the dough is mixed until the loaves are put into the oven. If the time must be shortened, twice or even three times as much yeast may be used and the sugar increased in about the same proportion. The dough must then, of course, be watched very closely, as there is more danger of letting the fermentation go too far.

Mixing.—A small quantity of the liquid, about one-half cup, must be set aside for softening the yeast. If milk is used, it must be scalded first

to check the growth of bacteria, and then cooled. In this case the part reserved for soaking the yeast should be cooled quickly, and the rest may be poured while still hot over the sugar, salt, and fat.

Other liquids than milk usually do not require heating, but often this is done for convenience in dissolving and melting the sugar, salt, and fat. In any case the liquid mixture should be brought to a temperature below 100° F. before mixing with the yeast. This exact temperature depends on that of the room and of the flour, and should be so adjusted to these as to bring the temperature of the dough to about 82° F.

The flour, except about 1 cup, should be added to the liquid and mixed thoroughly with a spoon, the hands, or a mechanical bread mixer. All the flour may be added at once if experience has shown the amount necessary. It is impossible, however, to tell beforehand exactly how much flour will be required unless flour from this lot has been used. The experienced bread maker tells by the "feel" of the dough when enough flour has been added. The quantity given in the above proportions is about right for rather strong flour. If the flour is extremely strong, 2½ pounds will be too much, but if it is of only average strength more will be needed. Usually, with a strong flour, the dough should be about as soft as it can be conveniently handled, but it should not be sticky. The quantity of flour varies also with the kind of liquid used. More flour is required with water than with milk.

With a new lot of flour it is a good plan to measure the quantity used and note the way it works. If results are satisfactory, the same methods and measurements may be repeated as long as that flour lasts.

Kneading.—When the flour and liquid are thoroughly mixed and the dough no longer sticks to the sides of the mixing bowl, it is ready to be kneaded. If a bread mixer is used, it kneads as well as mixes. If the bread is to be kneaded by hand, it should be turned out on a clean floured board and worked quickly with the palms of the hands until it is smooth and elastic. Dough made from hard-wheat flour requires more kneading than that made from soft-wheat flour.

First rising.—The dough should then be formed into a ball and put in a greased bowl to rise. The easiest way to keep the surface from drying and cracking is to turn the dough over once or twice in the bowl so that the whole surface of the dough is thinly

greased. Fat should be used sparingly, however, so that no streaks of it will show later in the bread. A clean cloth over the bowl and a plate or other tight cover will help to control the temperature, to keep out the dust, and to prevent drying. The bowl may be placed in a pan of warm water to raise the temperature of the dough, if it has cooled off, and keep it between 80° and 85° F. When the dough has risen to about double its original bulk, it should be tested with the finger to determine whether it is ready (p. 4) to punch down for a second rising.

Punching down.—When the dough is light enough, the center should be punched in, the sides pulled over and pressed into the center, and the ball of dough turned with the smooth side up. This can be done in less than a minute and is preferable to taking the dough out on the board. The purpose of punching down is to let out some of the gas so that fermentation can continue without injuring the gluten by causing it to stretch too far.

Second rising.—The second rising will not take so long as the first if the temperature is right. It may be omitted if necessary, but it helps to give a good texture and fine, even grain, especially if hard-wheat flour is used. When the dough has again risen to the same stage as before, it is ready to be punched down and divided.

Dividing.—The dough should be so divided that each baking pan will be about half full at first. After dividing, the dough should be rounded into balls to seal over the cut surfaces and allowed to stand a few minutes before molding.

Molding.—The loaves are molded by flattening each of them on the board into an oblong piece and then folding and sealing the edges together with the palms of the hands. This is repeated several times, each time folding a different way. The last time the sides are brought together into the center and the loaf is placed, sealed edges down, in a greased pan for the last rising. The top surface should be lightly greased.

Rising in the pans.—The temperature, from 80° to 85° F., should be just as carefully regulated during the last rising as for the two earlier periods. The pans may be set in warm water and covered with a clean cloth. When the loaves have about doubled in bulk the surface should be lightly pressed with the finger to test whether they are ready to be baked (p. 4).

Baking.—The oven should be fairly hot at first, about 400° to 415° F., de-

pending on the size of the loaf. A pound loaf should be baked at a higher temperature and more quickly than a pound-and-a-half loaf. Unless the oven bakes very evenly, the loaves should be turned around after they have been in about 20 minutes. The temperature of the oven may then be lowered a little. If a coal or wood range is used, the temperature at the start should be 400° F. or lower.

Baking will require from 45 minutes to 1 hour, depending upon the temperature of the oven and the size of the loaf. When the loaves shrink from the sides of the pan and give a hollow sound when tapped the bread is done. Brushing the loaves with milk or butter just before they are taken from the oven oftentimes improves the color of the crusts and makes them glossy and more tender but less crisp. As soon as the loaves are taken from the oven they should be turned out of the pans and placed on a rack to cool. They should not be covered while they are warm.

Sponge Method Using Dried Yeast Cakes

With dried yeast, which takes longer to become active than compressed yeast, it is generally more satisfactory to make a sponge early in the morning or the night before the bread is to be baked. With the following exceptions, the dough is mixed and handled in the same way as in the straight-dough method using compressed yeast:

The dried yeast cake should be broken up and soaked in lukewarm water until it is soft, or for about one-half hour before mixing.

If the sponge is to stand overnight, only about half as much yeast as called for in the proportions on page 4 is needed.

The liquid, the yeast, and half of the flour should be mixed and left until they form a light and frothy sponge. For a quick sponge the sugar also may be mixed with these other ingredients.

When the sponge is to rise overnight, ordinary room temperature (65° to 75° F.) is warm enough; but for a shorter sponge process the temperature ought to be the same as for dough (80° to 85° F.). When the sponge is light it should be stirred up well. The salt, sugar, melted fat, and the rest of the flour are then added to make a dough.

After the dough is mixed it is handled in the same way as in the straight-dough method.

BREAD FROM SOFT-WHEAT FLOURS

Soft-wheat flours, because of the smaller quantity or poorer quality of the gluten, require less moisture than hard-wheat flours to make a dough of the right consistency. Therefore proportionately less liquid or more flour is used, since the dough is made a little stiffer. It will not "tighten up" during the first rising as does hard-wheat flour dough. Instead it may become softer or "slacken" a little. The proportions for bread made with hard-wheat flour (p. 4) are based on $2\frac{3}{4}$ cups of liquid and $2\frac{1}{4}$ pounds, or $2\frac{1}{4}$ quarts, of flour. For the same quantity of liquid about $2\frac{1}{2}$ pounds, or $2\frac{3}{4}$ quarts, of sifted soft-wheat flour will be required.

Doughs made from soft-wheat flours rise more quickly than those made from harder ones, partly perhaps because, having less elasticity, they do not offer so much resistance to the gas bubbles formed by the yeast.

The quality of bread made from soft-wheat flour seems to be improved by using a comparatively large proportion of yeast and sugar to hasten the fermentation. If this dough is fermented for too long a period, the gluten is weakened. The proportions that seem to give the best results with soft-wheat flour are one yeast cake (one-half ounce) and one tablespoon of sugar for every pound loaf of bread. This is about double the quantity of each given in the standard proportions for bread made with hard-wheat flour (p. 4).

Soft-wheat flour doughs will not stand so much handling as those made with hard-wheat flour. If they are kneaded too hard or too long, the gluten will be injured.

Dough made from weak flour will not rise so high usually as one made from flour that has strong gluten. The fermentation of any dough should be checked before the gluten has reached the limit of its stretching power. Soft-wheat flour doughs usually reach this limit when they have about doubled their original bulk. To be safe, with a rather weak flour, the dough should be watched closely and tested with the finger before it has quite doubled in volume (p. 4).

HOME-GROWN OR SO-CALLED LIQUID YEASTS

One way to avoid the expense of using large quantities of compressed yeast, especially with soft-wheat flours, is to keep some kind of "starter" from one baking to the

next. Such a mixture is called "sponge," "ferment," "starter," or "liquid yeast," and is usually made from yeast, sugar, salt, water, and either potato or flour or both.

The following method of making liquid yeast with potato has proved particularly successful with soft-wheat flours:

3 potatoes ($\frac{3}{4}$ pound).
 $1\frac{1}{4}$ cups boiling water.
 $1\frac{1}{8}$ cups³ "starter" or 1 cake yeast ($\frac{1}{2}$ ounce) in $1\frac{1}{8}$ cups water.
 About $1\frac{1}{2}$ cups cold water.
 $3\frac{3}{4}$ tablespoons salt.
 $1\frac{1}{2}$ tablespoons salt.

Good, sound, clean potatoes must be used. Pare the potatoes, cut into small pieces, and cook until tender in the boiling water. Mash them in the water in which they were cooked. Add the sugar, salt, and enough cold water to make $3\frac{1}{4}$ cups of liquid, and allow this mixture to become lukewarm (about 82° F.). Add $1\frac{1}{8}$ cups of the starter reserved from the last baking. If none of this starter is available, one cake of dried or compressed yeast soaked in $1\frac{1}{8}$ cups of lukewarm water may be used instead. Allow this mixture to stand overnight. In the morning it should be light and frothy. Stir it well and pour off $1\frac{1}{8}$ cups to save as a starter for the next baking, and store this in a clean, sealed jar, loosely covered, in a cool place. In very cold weather it must be protected from freezing. The remainder is ready to use. The following directions for making bread from the liquid yeast are based on the use of soft-wheat flour:

About 2 $\frac{1}{2}$ pounds, or 3 quarts, sifted soft-wheat flour.
 5 tablespoons sugar.
 3 tablespoons fat.
 $3\frac{1}{4}$ cups liquid yeast.

Set the yeast for about half an hour in a pan of water of the right temperature to bring it to about 82° F. Add the fat and sugar and gradually stir in the flour. The exact quantity of flour required for a given quantity of liquid differs, of course, according to the strength of the flour. The dough should be rather stiff, and should be handled according to the general directions for soft-wheat flour yeast bread.

If bread is baked twice a week or oftener and the starter is cared for properly, there should be no trouble with spoilage. If bread is not baked this often, the starter should be renewed by making up a new mixture, as described, at least once a week; or,

if the weather is hot and no cool storage place is available, as often as twice a week. If the mixture should by any chance develop any unusual appearance or odor, it should be discarded and new starter made with clean materials and scalded utensils.

ROLLS

Yeast rolls are made by the same general method as loaf bread. They usually contain more sugar and shortening and sometimes egg, and milk is almost always used as the liquid. If sugar and shortening are increased, they tend to retard the growth of the yeast and the rolls take longer to rise. If desired, rolls may be made from bread dough by adding the extra sugar and shortening when the dough is ready to be punched down the first time. In this case, of course, more kneading is required in order to combine the materials thoroughly and it may be necessary to knead in more flour.

After rolls are molded and placed in the pan, they may be put in a refrigerator or other cold place to slow down the action of the yeast, and baked later. If the temperature has been so low that the rising is very much checked, they should be kept in a warm place for a little while before baking so that the volume will be about doubled.

PARKER HOUSE ROLLS (16 ROLLS)

1 cup milk.
 1 cake ($\frac{1}{2}$ ounce) yeast.
 $1\frac{1}{2}$ tablespoons butter or other fat.
 $1\frac{1}{2}$ teaspoons salt.
 1 tablespoon sugar.
 About $3\frac{1}{4}$ cups sifted hard-wheat flour, or 4 cups sifted soft-wheat flour.

The straight-dough method is perhaps the most convenient when only rolls are made. Allow the dough to rise the first time in the same way as for loaf bread. The dough may be permitted to rise again before it is shaped into biscuits, or the second rising of the dough may be omitted. Roll the dough out thin and cut with a biscuit cutter, or cut off small pieces from the dough, roll them into balls, and flatten with the palms of the hands. Brush the top part lightly with butter, crease through the center with the handle of a table knife, fold over, and press down the top. Brush the top with butter if a soft crust is preferred. When they have again doubled in bulk bake them quickly in a hot oven (425° F.) for 10 or 15 minutes.

³ $\frac{1}{2}$ cup = 2 tablespoons.

GRAHAM BREAD

Graham and so-called whole-wheat flours do not have so much baking strength as patent flour, and for that reason must be handled somewhat differently. The dough ferments more quickly and does not expand to so great a volume. Graham flour from hard wheat will make good bread without the addition of any white flour, but such flour from soft wheat, unless the bread is made with great skill, requires some patent or "straight" flour with it to make the bread light.

In the proportions given on page 4 graham may be substituted for all or part of the white flour. The dough should be slightly stiffer than that made with white flour, and it should not be allowed to rise so long. Also, graham bread should be baked more slowly than white bread.

RYE BREAD

Bread made entirely with rye flour or meal is heavy in comparison with wheat bread. In this country rye bread made with part wheat flour is preferred because it is lighter.

RYE AND WHEAT BREAD (2 LOAVES)

2 cups liquid.
 $\frac{1}{2}$ cake yeast.
 1 tablespoon sugar.
 2 tablespoons fat.
 $1\frac{1}{2}$ teaspoons salt.
 About 3 cups sifted rye flour.
 3 cups sifted wheat flour.

Make a sponge with the wheat flour as described on page 6. When the sponge is sufficiently light add the rye flour and the rest of the ingredients. The dough should be about as stiff as

for wheat bread. When the dough reaches about one and three-fourths its original bulk mold it into long loaves with pointed ends.

In order to make the crust crisp, bake in shallow pans with a thin layer of corn meal on the bottom instead of grease to prevent sticking. The temperature of the oven should be about 380° F.

QUICK BREADS, CAKES, COOKIES, AND PASTRY

PROPORTIONS AND INGREDIENTS

The fundamental proportions of some of the chief types of baked products are given in Table 2. These may, of course, be varied somewhat to meet individual tastes, but in general the relations indicated should be kept between the various ingredients. One cup of liquid is the basis used in most cases and from this quantities may be increased or decreased as desired.

A recipe for almost any kind of batter or dough mixture can be made by varying these proportions. Quick loaf breads may be made from the proportions for muffins by adding more flour and leavening; almost any kind of butter cake by varying the fat, sugar, egg, or flavoring; and meat-pie crust, shortcake, or fruit dumplings by slightly changing the proportions for biscuit.

The important differences in flours, liquids, leavening agents, and the other ingredients are pointed out so that the housekeeper will know when and how she can safely substitute with the supplies at hand.

TABLE 2.—Proportions for quick breads, cakes, cookies, and pastry

	Liquid (usually milk)	Flour (sifted soft wheat) ¹	Fat ²	Eggs	Baking powder	Sugar	Salt	Flavoring
Pop-overs.....	1 cup..	1 cup...	1 to 2 tea- spoons.	1 to 1½			$\frac{1}{4}$ teaspoon	
Waffles.....	do...	1½ cups.	2 table- spoons.	1 to 2.	2 teaspoons	1 table- spoon.	$\frac{1}{2}$ teaspoon	
Griddle cakes.....	do...	1½ cups	1 to 2 table- spoons.	1.....	do.....	0 to 1 ta- blespoon	do.....	
Fritter batter:								
No. 1, cover.....	do...	1¼ cups.	1 teaspoon.	1.....	1 teaspoon		$\frac{1}{2}$ teaspoon	
No. 2, binding.....	do...	1¼ cups	1 table- spoon.	1.....	2 teaspoons		$\frac{1}{2}$ teaspoon	
Muffins.....	do...	2 cups...	2 to 4 table- spoons.	1.....	do.....	1 to 2 ta- blespoons	do.....	
Cottage pudding.....	do...	2½ cups	$\frac{1}{4}$ to $\frac{1}{2}$ cup	1.....	3 teaspoons	$\frac{2}{3}$ cup..	$\frac{1}{4}$ teaspoon	$\frac{1}{2}$ teaspoon P. c.
Foundation cake.....	do...	3 cups...	$\frac{1}{2}$ cup..	2 to 3.	4 teaspoons	1½ cups.	do.....	
Baking - powder biscuit.....	do...	do...	4 to 6 table- spoons.		do.....		1 teaspoon	
Pastry.....	About 2½ table spoons water	1½ cups.	5½ to 7 ta- blespoons				do.....	

¹ Directions for substituting hard wheat flour are given on p. 9.

² These quantities are for fat containing no water. When butter or other fats containing water are used about one-sixth more should be allowed (p. 10).

FLOUR

How to substitute various types of wheat flours in quick breads, cakes, cookies, and pastry.—The quantities of flour recommended in Table 2 are for the soft wheat, or pastry, type. Hard-wheat flour may be substituted on the basis of seventh-eighths cup for each cup of soft-wheat flour, for these quantities weigh practically the same, since the hard-wheat flour is more compact. On the same basis of weight three-fourths cup of coarse graham or seventh-eighths cup of more finely ground graham flour, measured before sifting, may be used in place of 1 cup of sifted pastry flour.

LIQUID

Milk is the most desirable liquid to use in quick breads, cake, and cookies, because of flavor, texture, and food value. Whole milk, skimmed milk, or powdered or evaporated milk diluted to the proper consistency, gives practically the same results, except for variations in food value. In any product except pop-overs sour milk may be substituted for sweet, cup for cup, according to the general rules for leavening agents. In some cases a mixture of milk and water, or even water alone, may be used with no great loss in flavor or texture. In pastry, water is preferable. When cream is used as the liquid, it is not necessary to use so much other shortening.

LEAVENING AGENTS

With a few exceptions such as pop-overs, which are raised by water vapor, and sponge cakes, which are raised by water vapor and air, quick breads and cakes require baking powder or other chemical leavening agent.

Air may be beaten directly into the batter, but generally is added by means of beaten eggs. Though the air alone does not expand enough to leaven a mixture, it helps to make it light before baking, and its expansion supplements the effect of the water vapor and the chemical agent.

Water vapor is formed in a batter or dough during baking as the liquid in it becomes heated. The vapor thus formed raises the mixture just as it does the cover of a saucepan when there is enough pressure.

Baking powders.—Baking powders usually contain sodium bicarbonate and some acid-reacting material, such as cream of tartar, sodium aluminum sulfate, or a phosphate, mixed in the proper proportions, with starch to keep the chemicals dry. If baking powder becomes moist before it is used the soda and the acid start reacting,

gas is liberated, and the powder loses some of its leavening power. This is why baking powders should be kept tightly covered and in a dry place.

The commercial powders are classified according to the kind of acid-reacting material used, as tartrate, phosphate, or so-called alum powders. Some of these materials react more quickly than others, and commercial powders in some cases contain two of them, so that not all of the gas will be released at one time. None of the powders on the market are known to be harmful when used in the quantities needed for leavening.

In general, for each cup of flour in a batter or dough 1 to 1½ teaspoons of baking powder are needed. In butter cakes containing a large proportion of egg white this amount may be decreased. In pop-overs and true sponge cakes no baking powder is used.

Self-rising flours.—The products known as self-rising flours are composed of flour, salt, soda, and an acid-reacting material such as is used in commercial baking powders. Modern machinery makes it possible to weigh out these materials accurately and mix them more thoroughly than in the home. Directions sent with these flours should be used in the preparation of products from them, and no other leavening agent should be added.

Soda and sour milk or molasses.—Baking soda used with sour milk or molasses acts in practically the same way as baking powder in leavening a mixture. The soda should be mixed with the flour and other dry ingredients so that it will not begin to act until it is in the batter or dough. The old custom of putting the soda into the sour milk or molasses is not good practice, because as soon as they are mixed gas begins to escape.

If corn sirup or honey is used in place of molasses, the soda should be omitted, because these are only faintly acid, and baking powder or other leavening agent should be depended on for raising the mixture.

A scant half teaspoon of soda is about the right amount to use for each cup of sour milk or an even half teaspoon for a cup of molasses. It is better to use too little soda than too much, for an excess gives a disagreeable flavor and odor as well as the typical yellow color. *One scant teaspoon of soda, if there is plenty of acid to react with it, may be considered equivalent in leavening effect to four teaspoons of baking powder, because baking powder is about one-fourth soda.*

Substituting sour milk and soda for sweet milk and baking powder, or vice versa.—

When proportions are given in terms of sweet milk and baking powder, an equal quantity of sour milk may be substituted and enough soda used approximately to neutralize the acid, or a scant half teaspoon for each cup of sour milk. In the case of thin batters the soda and sour milk generally furnish enough leavening, but for thick batters or doughs baking powder is usually needed in addition. For instance, in the proportions for griddle cakes (p. 11) 1 cup of sweet milk and 2 teaspoons of baking powder may be replaced by 1 cup of sour milk and a scant half teaspoon of soda. This quantity of soda is not only right for the sour milk, but with the milk is approximately equivalent in leavening power to the 2 teaspoons of baking powder. For biscuits, which call for 1 cup of milk and 4 teaspoons of baking powder, if 1 cup of sour milk and a scant half teaspoon of soda were substituted, 2 teaspoons of baking powder would be needed also to be equivalent to the above quantity of baking powder.

When sweet milk is to be used in place of sour, baking powder is substituted for all of the soda in the proportion of 4 teaspoons of baking powder for 1 teaspoon of soda if no other acid ingredient such as molasses is used. If such an acid ingredient is used, as in gingerbread, some soda is required.

SHORTENING

Fat helps to make baked products tender and in some cases affects the flavor. Almost any mild-flavored, edible fat is satisfactory for most baking purposes. In general, above 7 parts of butter or margarine are required to give the same amount of fat as 6 of lard or similar fats containing no water. In substituting butter or margarine for the fat called for in Table 2 about 3 extra tablespoons for each cup of fat should be used.

BAKING TEMPERATURES

The heat during baking brings about five important changes in batters and doughs. It hastens the action of baking powder or other chemical leavening agent in forming gas. It causes some of the liquid in the mixture to change to water vapor, which aids in leavening. It hardens the proteins, particularly the gluten in flour and the albumen of egg, cooks the starch, and browns the crust.

The chief knack in baking, then, is to regulate the temperature so that the bread or cake will set as soon as

enough gas and water vapor have formed but before they have time to escape or condense.

The correct temperature for baking depends on the kind of leavening, on the proportions of ingredients, and on the size and shape of the product. So far as possible these points are considered in giving temperatures for each type of baked stuff. Large compact masses take longer to heat through than small, flat ones, and should therefore be baked more slowly. A large loaf cake, for example, needs lower temperature and longer baking than a layer cake.

For most products, if the temperature is right at the start it need not be changed during baking. A reliable oven thermometer or an automatic temperature regulator that has been tested is the surest means of knowing when the temperature is right. A suitable thermometer may be bought at relatively low cost and used in any type of oven.

Especially in baking cakes the oven door should be opened only when necessary and the pan should be moved as little as possible while the mixture is setting.

If baked at the right temperature, cakes and quick loaf breads may generally be considered done when they shrink from the pan, but for safety they may be tested with a clean straw or toothpick.

When the pans containing cakes in loaves or layers are taken from the oven they should be turned upside down until the cake cools partially and becomes firmer. Cake is too soft and hot for handling when it first comes from the oven. It should be removed from the pan, however, before it reaches room temperature or has a chance to sweat.

POP-OVERS, GRIDDLE CAKES, MUFFINS, AND THE LIKE

The so-called batter method of mixing is generally recommended for pour batters and for muffin and other plain drop batters, because it is quick and easy. The dry ingredients are mixed and sifted, the eggs are beaten slightly and added to the other liquid ingredients, which are then stirred gradually into the dry. The melted fat is added last to the batter rather than mixed with the liquids.

POP-OVERS (8 TO 12 POP-OVERS)

- 1 cup milk.
- 1 cup sifted soft-wheat flour.
- 1 to 2 teaspoons fat.
- 1 to 1½ eggs.
- ½ teaspoon salt.

Stir the liquid slowly into the dry ingredients to avoid forming lumps.

Fill hot, well-greased muffin pans, preferably iron or granite because they hold the heat, not more than half full of batter and place at once in a hot oven (about 425° F.). After about 20 minutes lower the temperature to about 350° F., so that the inside of the pop-overs will dry out a little without making the crusts too hard and brown. Pop-overs require baking about 45 minutes.

WAFFLES

- 1 cup milk.
- 1½ cups sifted soft-wheat flour.
- 2 tablespoons fat.
- 1 to 2 eggs.
- 2 teaspoons baking powder.
- 1 tablespoon sugar.
- ½ teaspoon salt.

In mixing, fold the beaten white of egg into the batter after all the other ingredients have been added. Have the waffle iron hot enough to brown the waffle quickly, and well greased unless it is the electrically heated aluminum kind. In that case add an extra tablespoon of melted shortening to the batter.

GRIDDLE CAKES (10 TO 24 CAKES)

- 1 cup milk.
- 1½ cups sifted soft-wheat flour.
- 1 to 2 tablespoons fat.
- 1 egg.
- 2 teaspoons baking powder.
- 0 to 1 tablespoon sugar.
- ½ teaspoon salt.

Mix the batter in the usual way (p. 10) and bake the cakes on a lightly greased hot griddle.

FRITTERS NO. 1

- 1 cup milk.
- 1½ cups sifted soft-wheat flour.
- 1 egg.
- 1 teaspoon fat.
- 1 teaspoon baking powder.
- ½ teaspoon salt.

Combine the liquid and the dry ingredients according to the method on page 10. Dip large pieces of fruits or vegetables, such as pineapple or tomatoes, into this cover batter and fry in deep fat at about 375° F.

FRITTERS NO. 2

- 1 cup milk.
- 1½ cups sifted soft-wheat flour.
- 1 tablespoon fat.
- 1 egg.
- 2 teaspoons baking powder.
- ½ teaspoon salt.

Mix the ingredients according to the method on page 10. This binding batter for fritters is generally used with small pieces of fruits or vegetables, such as corn cut from the cob, that would not be held together by the thinner cover batter described under "Fritters No. 1." When the vegetable or fruit has liquid with it, as in canned corn, this may take the

place of part of the liquid in the batter. Fry these fritters in deep fat at about 365° F., because they need time to cook through to the center, whereas the other type usually needs to be cooked only on the outside.

MUFFINS (10 TO 12 MUFFINS)

- 1 cup milk.
- 2 cups sifted soft-wheat flour.
- 2 to 4 tablespoons fat.
- 1 egg.
- 2 teaspoons baking powder.
- 1 to 2 tablespoons sugar.
- ½ teaspoon salt.

Mix according to the method on page 10 and bake in greased tins in a hot oven (400° to 425° F.).

QUICK LOAF BREADS

Fruit, nut, and other quick loaf breads are made from a mixture like that for muffins only slightly thicker in some cases. If the batter is comparatively thin, the fruit or nuts should be floured before being added. The temperature of the oven should be low enough for the bread to bake through without making the crust too hard or brown. For a small loaf a temperature of 375° F. is about right; for a large loaf it should be lower. Before taking the bread from the oven it should be tested with a straw or a toothpick to make sure that the inside is cooked. Sometimes the leavening does not work quickly enough if the mixture is rather thick. In that case it should be allowed to stand for 20 to 30 minutes in the baking pan before it is put into the oven.

GINGERBREAD (2 THIN LOAVES)

- 1 cup milk.
- 3½ cups sifted soft-wheat flour.
- ½ cup fat.
- 1 egg.
- ½ teaspoon soda.
- 4 teaspoons baking powder.
- ½ cup sugar.
- 1 cup molasses.
- ½ teaspoon salt.
- 1 teaspoon ginger.
- ½ teaspoon cloves.
- ½ teaspoon cinnamon.

Stir the liquid into the dry ingredients (p. 10). Since gingerbread is richer than muffins, it is more likely to fall in the oven if not properly baked. For a shallow loaf the oven should be moderate (about 375° F.); if muffin pans are used, it should be fairly hot, or about 400° F.

Sour milk may be used instead of sweet in the same quantity, but in that case the soda should be increased to a scant teaspoon and the baking powder decreased to 2 teaspoons.

BISCUITS AND PASTRY

All dry materials are mixed and sifted together, the fat is worked in,

and the liquid is added to this fat-and-flour mixture. For rich pastry all the materials should be mixed cold so that the fat will not become soft. For a mixture containing only $5\frac{1}{2}$ tablespoons of fat in $1\frac{1}{2}$ cups of flour especially if hard fat is used, it is better to have the materials at room temperature (about 70° F.). Cutting the fat into the flour with knives, a pastry fork, or a biscuit cutter is often recommended to avoid warming or handling it too much, but the tips of the fingers may be used if the work is done quickly. When oil instead of solid fat is used, it is generally better to combine the oil with the liquid. The dough should be worked as little and lightly as possible so that the gluten will not be developed too much and the product made tough.

BISCUITS (24 TO 30 BISCUITS)

- 1 cup milk.
- 3 cups sifted soft-wheat flour.
- 4 to 6 tablespoons fat.
- 4 teaspoons baking powder.
- 1 teaspoon salt.

Either milk or water may be used as the liquid in baking-powder biscuits, and the quantity varied to obtain the kind of biscuit desired. Some persons prefer the texture of a biscuit made from very stiff dough, using as little liquid as possible. Others like a lighter biscuit, for which the dough is made very soft by using more liquid and combining very lightly. Drop biscuits which are not rolled out may be made by adding still more liquid than for a soft dough.

Mix the ingredients according to the method given above and bake the biscuits in a shallow pan or on a baking sheet. The pan should be lightly greased for drop biscuits, but this is not necessary for the other types. Biscuits require a very hot oven (450° to 500° F.).

Sour milk may be substituted for the sweet called for in these proportions according to the rules given on page 9.

MEAT-PIE CRUST

Crust for meat pie is made in the same way as biscuit dough by using a little more fat. Fat from the meat may be used for shortening. The dough is rolled or patted out about one-half inch thick to the proper size for the baking dish, placed on top of the filling, and baked at about 425° F., that is, at slightly lower temperature than for biscuits. The crust bakes better if the filling is hot at the start.

SHORTCAKE

Shortcake dough is also similar to that for biscuits except that it con-

tains fat in the proportion of one-third to one-half cup to three cups of flour and sometimes a little sugar. Shortcake is usually baked in two layers, one on top of the other wiped with butter between, so that it will split easily. The oven should be rather hot (425° F. for a large sheet or 450° for individual shortcakes).

PLAIN PIE CRUST (1 TWO-CRUST PIE)

- About $2\frac{1}{4}$ tablespoons water.
- $1\frac{1}{4}$ cups sifted soft-wheat flour.
- $5\frac{1}{2}$ to 7 tablespoons fat.
- 1 teaspoon salt.

Combine fat and flour according to directions given. Add the water slowly and use no more than is absolutely necessary. Roll the dough very lightly. If the lower crust is baked separately, the oven should be about 450° F. However, a pie with a filling that needs to be cooked can not be left long in an oven as hot as this, because the crust bakes too fast for the filling. The temperature should be high (about 450° F.) to start and then lowered rapidly after 8 or 10 minutes so that the filling may cook through without overcooking the crust.

CAKES, DOUGHNUTS, AND COOKIES

Cakes are mixed by different methods depending on whether they contain a large proportion of fat, as in the so-called butter cakes, or whether, like sponge cakes, they contain no fat and are leavened by means of beaten eggs. The methods of mixing are therefore given with the other directions for making cakes of these types. The less rich mixtures, such as cottage pudding, can be successfully combined in the same way as muffins (p. 10).

COTTAGE PUDDING (1 LARGE THIN LOAF)

- 1 cup milk.
- $2\frac{1}{4}$ cups sifted soft-wheat flour.
- $\frac{3}{4}$ to $1\frac{1}{4}$ cup fat.
- 1 egg.
- 3 teaspoons baking powder.
- $\frac{2}{3}$ cup sugar.
- $\frac{1}{4}$ teaspoon salt.
- $\frac{1}{2}$ teaspoon flavoring.

Mix the ingredients in the same way as for muffins (p. 10). Bake in a fairly hot oven (about 390° F.) if muffin pans are used; or at a more moderate temperature (about 365° F.) if in a thin loaf. Cottage pudding is usually served hot with a sauce.

BUTTER CAKES

Butter cake is the term often given to this group containing butter or other fat to distinguish them from the sponge cakes, which contain no shortening.

The proportions for plain, founday tion, and rich butter cakes are given

TABLE 3.—Proportions for three types of butter cakes

Ingredients	Plain cake	Foundation cake	Rich cake
Milk.....	1½ cups.....	1 cup.....	1 cup.....
Flour (soft wheat).....	3 cups.....	3 cups.....	3 cups.....
Fat ¹	½ cup.....	½ cup.....	1 cup.....
Eggs.....	1.....	2 to 3.....	4.....
Baking powder.....	5 teaspoons.....	4 teaspoons.....	4 teaspoons.....
Sugar.....	1½ cups.....	1½ cups.....	2 cups.....
Salt.....	¼ teaspoon.....	¼ teaspoon.....	¼ teaspoon.....
Flavoring.....	½ teaspoon.....	½ teaspoon.....	½ teaspoon.....

¹ These proportions are for fat containing no water. If butter or other fat containing water is used, about 3 tablespoons more for each cup of fat should be allowed.

in Table 3. The foundation cake is rich enough for most purposes; especially if baked in layers and put together with filling. These quantities will make two thick or three thin layers.

Though the ingredients of these cakes may be combined by the method used for muffins with fairly good results, with slightly more effort better texture may be produced in the following way: Place the fat in a warm place until it becomes soft, though not melted, so that it may be combined easily with the sugar. This is just as satisfactory and much quicker than the laborious method of creaming together the cold fat and sugar. After the fat and sugar have been thoroughly combined stir in the beaten egg yolks and add alternately the dry ingredients, which have been mixed and sifted together, and the liquid. At the start add only a small quantity of liquid. If too much is added, it dissolves the sugar, and the fat separates into large masses that must be recombined with the other ingredients by beating, thus making useless the work of combining the fat and sugar in the beginning. Add the flavoring and fold in the well-beaten egg whites. Pour the batter into lightly greased, floured pans, taking care that it is spread evenly. If baked in a thick loaf, the oven temperature should be very moderate (about 325° F.); but if baked as cup cakes or thin layers the oven should be about 375° F.

Substitutions.—Recipes calling for a relatively large number of eggs may sometimes be made more cheaply by using fewer eggs, though a less desirable product results. More milk or water should be added to take the place of the liquid of the eggs and more baking powder for leavening. In general, for each egg left out about 2 tablespoons of liquid and one-half teaspoon of baking powder should be added, as shown in the proportions for plain and foundation cake. This

substitution is more successful usually in cakes which have a relatively low proportion of fat.

Chocolate may take the place of some fat and flour. One ounce of chocolate may be considered the equivalent of about 1 tablespoon of fat and 1 tablespoon of flour, and should be melted and added to the batter just before the egg whites are folded in.

Whites or yolks of eggs may be used instead of whole eggs in making fancy white or yellow cakes, or as an economy in using up parts of eggs left over. For most purposes 2 whites or 2 yolks may be considered roughly the equivalent of 1 egg. When yolks alone are used, a little extra baking powder is sometimes needed, since air can not be combined so readily as in the case of the egg whites.

SPONGE CAKES

The cakes made without fat are called sponge cake, sunshine cake, and angel food, depending on whether the same number of egg yolks and whites, a large proportion of whites, or only whites are used. Eggs supply the liquid in these cakes and serve as a means of adding air for leavening. Lemon juice or cream of tartar is added, because the acid affects the egg in such a way as to make the cake more tender. Fine, soft-wheat flour gives best results in cakes of this type. The quantities given will make two medium-sized loaves each.

Because of their delicate texture sponge cakes require more careful mixing and baking than other types. The usual method of mixing plain sponge cakes is as follows: Add the sugar to the beaten egg yolks and then the flour and half the salt after the flour has been sifted. Add the other half of the salt to the egg whites, beat them stiff, fold them into the mixture, and add the flavoring last. For beating the eggs a Dover beater gives satisfactory results and requires less time and energy than a wire

TABLE 4.—Proportions for sponge cakes

Ingredients	Sponge cake	Sunshine cake	Angel food
Flour (soft wheat).....	1 cup.....	1 cup.....	1 cup.....
Eggs.....	1 cup (4 or 5 eggs).....	1 cup (6 whites and 3 yolks).....	1 cup whites (8 fairly large).....
Sugar.....	1 cup.....	1 to 1½ cups.....	1 to 1½ cups.....
Salt.....	½ teaspoon.....	½ teaspoon.....	½ teaspoon.....
Flavoring and acid.....	3 teaspoons lemon juice..... ½ lemon rind grated....	1 teaspoon flavoring.... 1 teaspoon cream of tartar.....	1 teaspoon flavoring.... 1 teaspoon cream of tartar.....

whisk. Pour the batter, as soon as it is mixed, into smooth, ungreased baking pans. For a large or medium-sized loaf a tube pan is best, because the center opening allows the mixture to heat evenly. Powdered sugar may be sifted over the top to make the crust more crisp. The oven should be ready for the cake as soon as it is mixed and in the pan. A large or medium-sized sponge cake should be baked slowly at about 325° F., small cakes at somewhat higher temperature, or about 340° F.

Sunshine cake is mixed and baked in the same way as plain sponge cake, except that some of the beaten whites are mixed with the yolks and sugar to help moisten them before all of the flour is added.

Angel food is mixed in a slightly different way than plain sponge cake. The sugar, flour, and half the salt are sifted together several times. The egg whites are beaten with the other half of the salt until they are frothy; then the cream of tartar is added and they are beaten until stiff. The dry ingredients are then folded carefully into the beaten egg whites, and when the mixture is partly blended the flavoring is added. Only the folding motion should be used in mixing, for stirring tends to release the air depended on for leavening. A smooth tube pan is best for baking angel food, and a fairly large cake will require about an hour in an oven at a temperature of 325° F. It may be tested in the same way as any other cake.

Substitutions.—The proportions for sponge cake and angel food given in Table 4 may be modified by substituting milk or water and baking powder for one or two of the eggs according to the general rule of two tablespoons of liquid and one-half teaspoon of baking powder for each egg omitted. In this case the leavening is sifted with the flour and the liquid is added before the egg whites are folded into the batter. Cakes of this kind may be baked at a temperature slightly

higher (about 340° F. for a loaf) than is used for true sponge cakes.

DOUGHNUTS (40 DOUGHNUTS)

- 1 cup milk.
- 4½ cups sifted soft-wheat flour.
- 2 teaspoons fat.
- 2 eggs.
- 5 teaspoons baking powder.
- 1 cup sugar.
- 2 teaspoons salt.
- ½ teaspoon cinnamon.
- ½ teaspoon nutmeg.

Mix the ingredients according to the method for butter cakes (p. 12), roll out the dough about one-third inch thick without handling it any more than necessary, cut out the doughnuts, and fry in deep fat hot enough (about 375° F.) to make a doughnut rise to the surface quickly and to brown each side in about one minute.

DROP COOKIES (50 COOKIES)

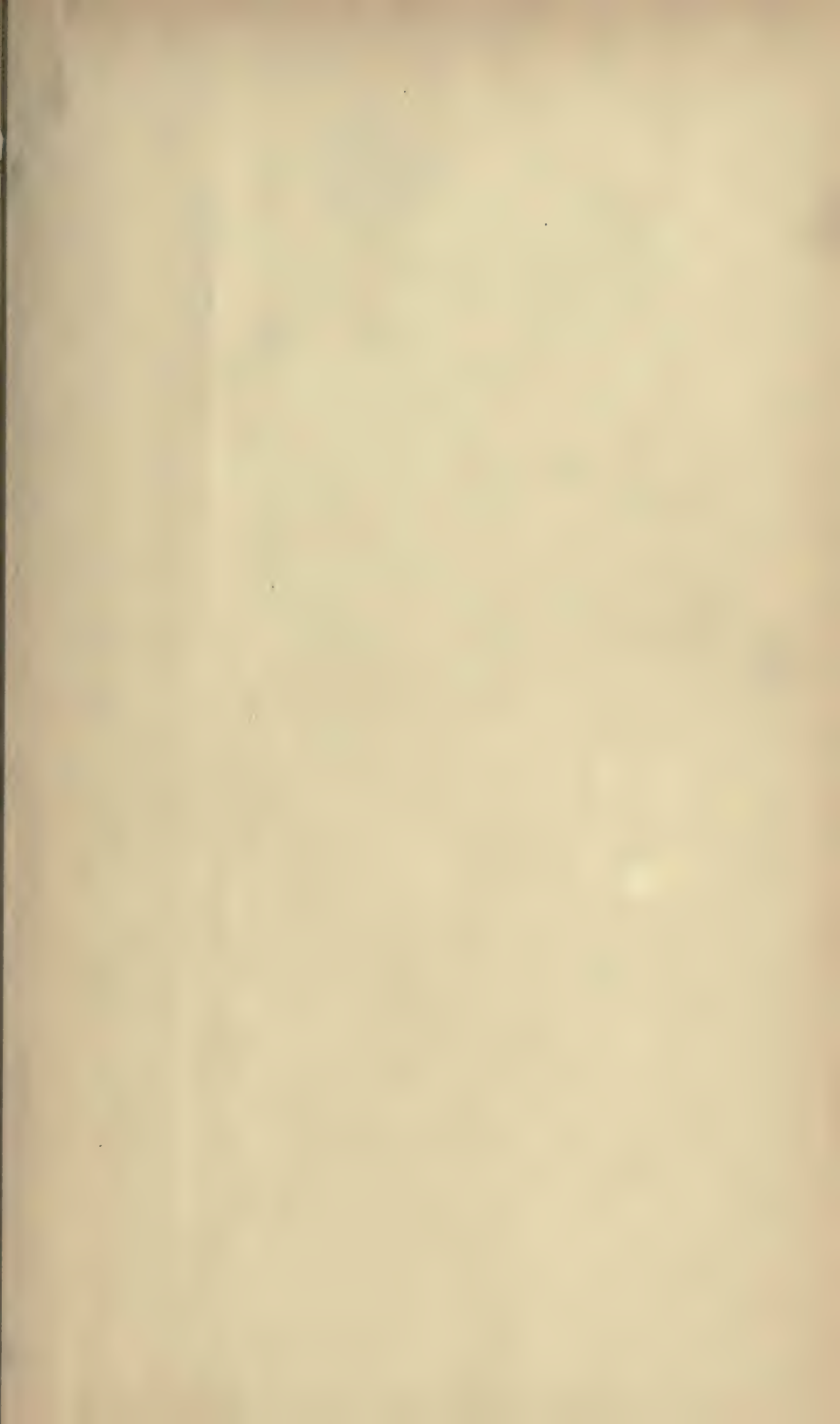
- ¾ cup milk.
- 4 cups sifted soft-wheat flour.
- ¾ cup fat.
- 2 eggs.
- 4 teaspoons baking powder.
- 1½ cups sugar.
- ½ teaspoon salt.
- 3 teaspoons flavoring.

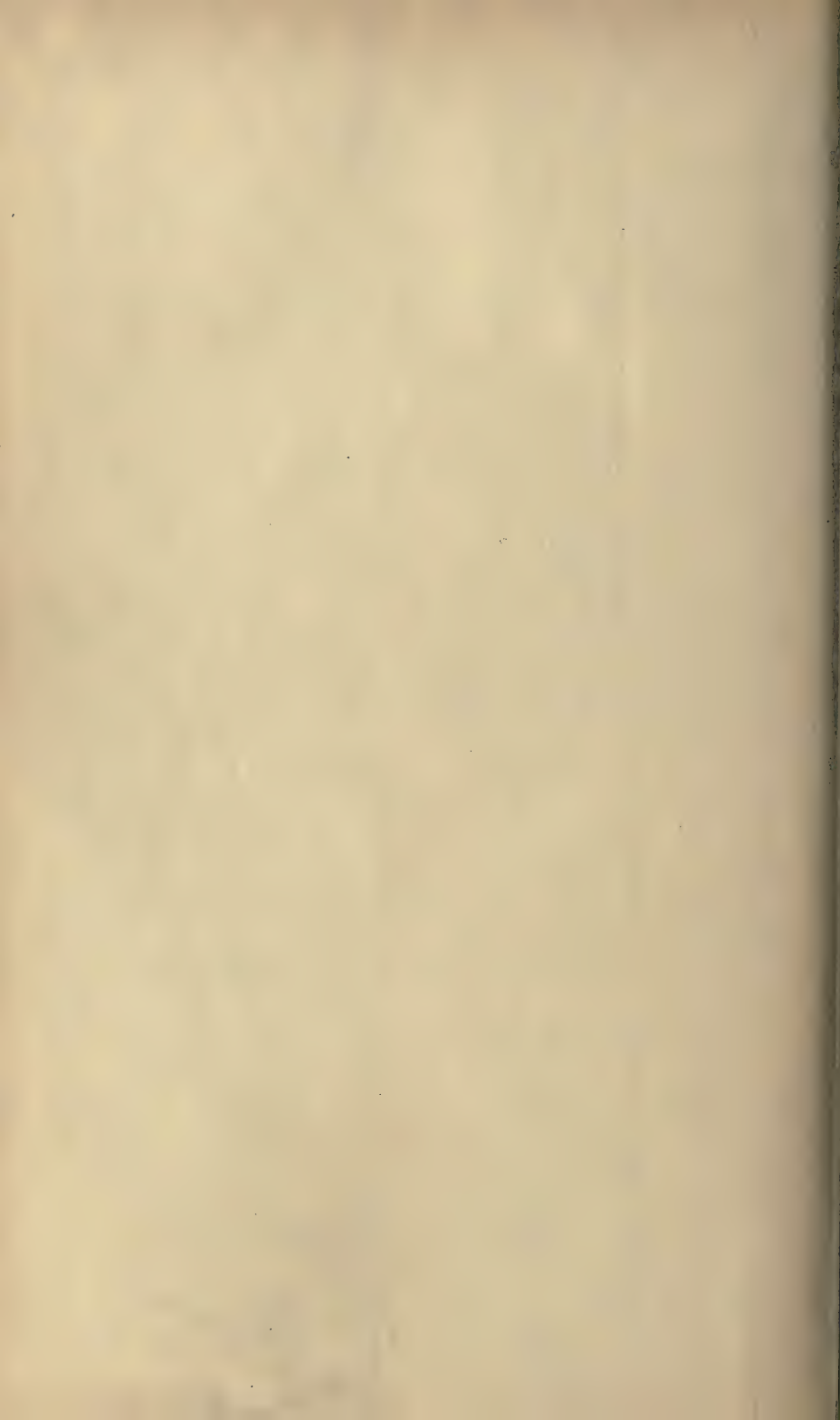
Mix the ingredients according to the method given for butter cake (p. 12). Drop small portions of the mixture on a greased baking sheet and bake in a moderately hot oven (about 375° F.).

CRISP COOKIES (100 THIN COOKIES)

- ¼ cup milk or less.
- 4 cups sifted soft-wheat flour.
- 1 cup fat.
- 2 eggs.
- 4 teaspoons baking powder
- 2 cups sugar.
- ½ teaspoon salt.
- 3 teaspoons flavoring.

Combine the ingredients in the same way as for butter cakes (p. 12), roll the dough thin, handling it no more than necessary, cut it in any desired shapes, and bake the cookies on a greased baking sheet in a fairly hot oven (about 375° to 400° F.). Instead of rolling out the dough it may be chilled and sliced thinly. Whether rolled or sliced, chilling the dough makes it easier to handle.





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